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DEPARTMENT OF ENERGY'S FOSSIL ENERGY RESEARCH AND DEVELOPMENT AND CLEAN COAL TECHNOLOGY PROGRAMS

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON THE

DEPARTMENT OF ENERGY'S FOSSIL ENERGY RESEARCH AND DEVELOPMENT AND CLEAN COAL TECHNOLOGY PROGRAMS

JULY 11, 1989

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DEPARTMENT OF ENERGY'S FOSSIL ENERGY RESEARCH AND DEVELOPMENT AND CLEAN COAL TECHNOLOGY PROGRAMS

TUESDAY, JULY 11, 1989

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:34 p.m., in room SD-366, Dirksen Senate Office Building, Hon. Wendell H. Ford presiding.

OPENING STATEMENT OF HON. WENDELL H. FORD, U.S. SENATOR FROM KENTUCKY

Senator FORD. Good afternoon, ladies and gentlemen.

Energy security, environmental improvement and U.S. jobs are essential to the economic future of our Nation. Fossil fuels supply nearly 90 percent of our country's energy requirements. Fossil research and development must be the cornerstone of our efforts to preserve and improve U.S. competitiveness, preserve U.S. advances in technology development and keep U.S. jobs in the United States.

It isn't long ago that we were far too dependent on foreign oil. This country worked hard to achieve a 50 percent decline in imports between 1977 and 1985. We must not forget those efforts. In fact, we must renew those efforts. If we do not, the level of energy imports will soon be above 50 percent.

The dangers of increasing our dependence on foreign energy sources are obvious. We can and must minimize this danger by expanding the slate of technologies that uses domestic energy resources. Federal R&D efforts are essential to expanding our knowledge in this area. We can't fall back into a situation like we were in during the 1970s.

Why then does DOE propose to make a 50 percent cut in the level of funding for its fossil fuel energy programs? Many of these cuts come in research and development for technologies that are efficient, cost effective and better for the environment than what we use today. We have lost more than 50,000 coal mining jobs since 1980. We are also fighting an uphill battle to clean up our air without destroying the economy. The tie between our energy needs, our economy and the environment is an important one, one that deserves full attention and full funding.

One of the most visible programs related to energy and the environment is the clean coal technology program. Clean coal technol-

ogies are the most promising technologies for helping deal with the environmental consequences of burning coal. I am pleased that the Bush budget restores clean coal funding to its original level and original time schedule. A strong Federal effort to develop clean coal technologies is essential to our environmental and our economic future. This program is too important to cut or slow down. We must develop these technologies in all regions of the country and that use of all types of coal, and we must do it soon.

To be successful in meeting our national goals, however, we must go beyond the demonstration of these energy technologies. We must ensure that these technologies will be deployed. I am interested in learning more about DOE's actions to reduce the risk and lessen the regulatory barriers to the deployment of clean coal technologies. I am also interested in DOE's views on how clean coal technologies will help meet our future environmental goals.

Secretary Wampler and the other distinguished witnesses that will be here today, I welcome you here to talk with us today about the Department of Energy's 1990 budget for fossil energy research. Welcome, Mr. Secretary, and let us proceed.

[The prepared statement of Senator Gore follows:]

ALBERT GORE, JR.
TENNESSEE

393 RUSSELL SENATE OFFICE BUILDING
PHONE: 202-224-4944

United States Senate

WASHINGTON, DC 20510

July 11, 1989

Hon. Wendell H. Ford, Chairman
Subcommittee on Energy, Research and Development
312 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed is a statement I have prepared concerning the magnetohydrodynamics (MHD) project. I respectfully request that this statement be included in the record of this afternoon's hearings on the FY90-91 authorization for civilian energy programs under DoE.

It is my understanding that the relevant House committee has approved $42.9 million for MHD in FY90. I support the authorization of this level of funding for the reasons outlined in my statement. Certainly, I would not like to see anything less than this year's allocation of $37 million.

Thank you for your attention to this request. I would genuinely appreciate your continued support for the MHD program.

Sincerely,

Albert Gore, Jr.
U. S. Senator

AG/wem
enclosure

Albert Gore Jr.

SENATOR ALBERT GORE JR.

TO THE SENATE SUBCOMMITTEE ON ENERGY, RESEARCH & DEVELOPMENT

July 11, 1989

Mr. Chairman, I appreciate this opportunity to address the Subcommittee, specifically to comment on magnetohydrodynamics (MHD) program, a coal-burning project that could substantially reduce emissions from coal burning and decrease the United States' dependence on foreign energy sources. The first successful MHD generation tests were in the United States; and steady progress has been made in this important technology, which is nearing commercialization. The MHD program merits support, and I urge the Subcommittee to continue an adequate level of funding.

There have been attempts to eliminate the program in the past, and I was dismayed to see that the Administration once again is seeking to zero funds for MHD with the rationalization that the technology is not affordable under current budget restraints. Mr. Chairman, Congress has refused in recent years to let the investment in MHD be lost and allocated $37 million for the program in FY89. We simply cannot afford to stop the MHD program dead in its tracks. MHD is a long range program with great benefits within sight, but the private sector cannot finance its development alone.

Mr. Chairman, I have been a consistent supporter of this impressive technology. MHD promises 50 percent more efficient use of coal and significant reduction in acid rain and greenhouse gas emissions. In this process, finely-crushed coal is burned at 5000 degrees and an electrically-conducting gas or "plasma" is passed across a magnetic field, producing an electrical current. Thus, power is directly converted into electrical energy without the intermediate mechanical step such as turning turbines in a conventional power plant. As a bonus, the exhaust heat can power a conventional steam plant, resulting in an MHD/steam combined cycle power plant that produces 50 percent more electrical power than a conventional steam power plant.

In September, the MHD power plant in Tullahoma, Tennessee, ran continuously for a record 111 hours during a two-week, 250 hour test. In contrast, in the early 1980s, test runs of five to ten minutes were considered long. The University of Tennessee Space Institute (UTSI) has pioneered work on coal-fired MHD power generation through the Energy Conversion Research and Development Programs in Tullahoma. UTSI's Coal Fired Flow Facility is an integral part of the Department of Energy's program to retrofit an MHD system to an existing electric power plant in the early 1990s.

Testing at UTSI is proving the feasibility of the concept as well as providing critical data required for production of commercial-scale power plant equipment. Information from the UTSI tests will reduce the risk of implementing this technology on a larger scale, thereby encouraging utilities to invest in it. Of course, I am proud that Tennessee has been a leader in the MHD program, but important projects are also under way in Montana. Diagnostic testing efforts are centered in Mississippi. The construction of superconducting magnets takes place in California. Other testing programs are in Massachusetts, Pennsylvania, and Florida. We have the lead in MHD technology.

Since MHD burns coal 50 percent more efficiently and cleanly than any existing technology, it represents one of our best hopes for addressing environmental concerns associated with coal-fired electricity generation. In addition, at UTSI, the facility burns both eastern and western coals: Illinois #6 and Montana Rosebud.

Mr. Chairman, as you know, I have been active in Congressional efforts to understand the greenhouse effect and develop policies to prevent it, I am impressed by the results of the prototype MHD facility in Tullahoma. The reduction of carbon

dioxide emissions alone could have a tremendous impact. Equally important, MHD reduces sulfur dioxide (SO2) emissions to one-seventh the Environmental Protection Agency requirement. Nitrogen oxide (NOx) emissions and particulates are also well below EPA standards. I cannot overemphasize the importance of this technology in efforts to ameliorate the greenhouse effect and acid rain problems.

Using MHD technology would also increase our energy independence. The United States is the "Saudi Arabia of coal." We have 29 percent of the world's coal reserves, and increased use of coal in an environmentally-sound manner would enhance U.S. energy security by reducing our dependence on foreign sources of oil.

In addition to its use as a stationary power source, MHD power generation is well-suited for special applications when power "bursts" are required. For example, MHD can be used in geophysical research for electromagnetic probing of the earth's crust. Some scientists point out that MHD could be used for weapons systems. Reports indicate that the Soviet Union used an MHD generator to power a laser in 1985.

Mr. Chairman, I also believe it is essential for our Nation to maintain its lead in MHD technology. Although Congress decided to allocate $37 million in FY89, other nations are investing heavily in this promising technology.

The Soviet Union, with the second largest coal reserves in the world, is one of our chief rivals for dominance in MHD technology. In addition to developing a commercial MHD plant, the Soviets are also trying to develop a pulsed MHD generator, which, as I mentioned, could be applied to power lasers. The Soviets have cooperative programs with Finland, India, Yugoslavia, Bulgaria, Hungary, Poland, Rumania, and Czechoslovakia, and the Soviets expect to operate a commercial MHD plant by the 1990s.

Equally striking, an Italian consortium, administered by the University of Bologna, plans to spend $100 million on a program to retrofit one gas-fired and one coal-fired electric power plant with MHD technology, eventually using that experience to market MHD equipment internationally. That the University of Bologna has taken such a prominent role in the Italian project underscores the need for the U.S. to develop better technology transfer programs here at home. The Italians plan to market

their MHD equipment worldwide in the 1990s and could become a major competitor with U.S. industry in the power plant market.

Elsewhere, Israel and France are at work on liquid metal MHD. Japan, the Netherlands, Italy, and Austria are pursuing closed-cycle noble gas MHD. With the third largest coal reserves in the world, China has begun serious work on MHD. Japan, focusing on education and the future, is training specialists in the technology at universities.

Once again, we are in danger of letting our technological lead slip. We hear that so often it has almost become a cliche. But in a world where environmental concerns are becoming more urgent and market competition for more efficient energy systems has gotten tougher, MHD technology could be a big seller. If we do not continue to invest in and develop MHD, I am concerned that the United States might depend on foreign sources of MHD technology just as we now depend heavily on foreign sources of energy.

We have been slow to take advantage of our technological lead in MHD, and we have been slow to join international cooperative programs. There is serious concern in the MHD

community about the gradual erosion of the United States' technological leadership and our international competitiveness.

At the least, the United States must maintain the present DOE/industry proof-of-concept program which will provide the engineering data required to retrofit an MHD unit to an existing power plant in the early 1990s. The Senate once again this year should provide adequate funds for MHD under the Fossil Energy Research and Development Program in the DoE. I urge the Subcommittee to to keep the MHD program strong by continuing to support this promising, vital program.

Senator WIRTH. Mr. Chairman?

Senator FORD. Oh, excuse me. I am sorry. You were on the phone and you came in so quietly.

Senator WIRTH. I always come in quietly, Mr. Chairman.

Senator FORD. I apologize, and we have another one down here too. Goodness.

Senator WIRTH. Would you recognize, Mr. Chairman, one of us?

Senator FORD. Either one. Which one is the tallest? [Laughter.]

Senator WIRTH. He may be taller, but I'm quicker, Mr. Chairman. [Laughter.]

STATEMENT OF HON. TIMOTHY E. WIRTH, U.S. SENATOR FROM COLORADO

Senator WIRTH. Thank you, Mr. Chairman. I just want to very briefly welcome Secretary Wampler here.

I have always been a supporter of the clean coal program, Mr. Chairman. One of the items that has disappointed me and is going to be the focus of my questions either oral or written is why the clean coal program, despite rhetoric to the contrary, has not picked out any projects related to western coal. You have I know in a welcome fashion been focusing on coming out and had a meeting in Denver and so on I know, but we still haven't seen anything more than rhetoric. And it seems to me that as we look at this extraordinarily abundant research outlined in the Chairman's opening comments and as we recognize that we are going to be burning coal for a long time to come—whether some like it or don't like it, coal is going to be a fuel of major use for a long time, and western coal is going to be a fuel of major use for a long time—why have we not seen any commitment to western coal.

I just want to point out to you that there as many votes in the west as there are elsewhere, Mr. Secretary, and if we get to that point, we will start exercising those votes related to this program. So, I would just like you to—we have been supporting it. Those of us in the west have supported this program, but I think that there are a number of initiatives that can be taken related to western coal and the kinds of issues we have which are significantly different from those of the Appalachian area which we recognize and are sympathetic with. So, I would hope that during the course of the day you might be able to focus some of your comments on that.

Thank you, Mr. Chairman.

Senator FORD. May I say to my distinguished colleague that we were involved in the Kentucky H process. And during that pilot project, which was terminated by the Reagan Administration, the State of Kentucky offset the transportation charge to bring western coal into east Kentucky so that we might find out how we could use yours and how it would comply to the H process. So, I am very familiar and very anxious to see that you are accommodated like all the rest.

Senator WIRTH. Thank you very much, Mr. Chairman. I wish the Department of Energy were as accommodating as the State of Kentucky. Maybe we can get them to be that way.

Senator FORD. Well, if they hadn't terminated the program, we would still be going. It was setting a Guinness Book of Records at the time it was terminated.

Senator Rockefeller.

STATEMENT OF HON. JOHN D. ROCKEFELLER IV, U.S. SENATOR FROM WEST VIRGINIA

Senator ROCKEFELLER. Thank you, Mr. Chairman. I echo in a sense what you both said, excise the word "western', and that is that I think it is time to get out of the research part of this clean coal technology and get into the deployment part of it. We face a rising demand for electricity with the prospect of brownouts in the short term and a supply crisis almost certain in the longer term. We face the ominous rise in our dependence upon imported oil. We confront a rising controversy over environmental matters. All these developments point toward the need for more rather than less fossil energy research and development.

And, of course, we need R&D in other areas too, such as renewable energy. Of course, we will continue to debate the environmental issues, but whatever side of that debate one is on, everyone should be able to agree on the need for stronger fossil energy research and development.

In the specific case of clean coal technology, it strikes me again that we need to move into the deployment phase so that we can put this new technology to use. A stronger fossil fuel research and development must be a key element in our national energy policy.

In my own work on alternative fuels, I have emphasized the basic purpose of our national energy policy must be to anticipate the problems that are crowding in on us and somehow regain control of our future. We fail to seem to be able to do that. We cannot afford a lack of imagination regarding the possibilities of innovation. And therefore, I look forward to what our witnesses have to say.

And I thank the Chair.

Senator FORD. Thank you, Senator.

Mr. Secretary, you may proceed.

STATEMENT OF HON. J. ALLEN WAMPLER, ASSISTANT SECRETARY FOR FOSSIL ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY JEREMIAH E. WALSH, JR., DEPUTY ASSISTANT SECRETARY FOR MANAGEMENT, FUNDAMENTAL RESEARCH AND COOPERATIVE DEVELOPMENT, AND JACK S. SIEGEL, DEPUTY ASSISTANT SECRETARY FOR COAL TECHNOLOGY

Mr. WAMPLER. Thank you, Mr. Chairman.

Mr. Chairman and members of the subcommittee, I am pleased today to present the Department's fiscal year 1990 budget for fossil energy research and development and the Nation's clean coal technology program.

Mr. Jerry Walsh, my Deputy Assistant Secretary for Management, is seated to my left. Mr. Jack Siegel, the Deputy Assistant Secretary for Coal Technology, is seated to my right. And as usual, I have a large number of staff to assist me, if necessary, in the room.

The prepared statement that I have submitted, Mr. Chairman, is admittedly very lengthy and I would appreciate the subcommittee's consideration in placing the full text of that testimony in the record. The major elements of our fiscal year 1990 budget proposal are discussed in the first 16 pages of that statement, and with the subcommittee's permission, I would like to briefly highlight those key themes.

Our budget request reflects President Bush's decision to reinstate the five-year funding schedule for the Clean Coal Technology Program. The President is committed to this program. He views it as a key element of his recently announced proposal to revise the Clean Air Act and to resolve, once and for all, the issue of acid rain.

Currently we have 29 clean coal projects either under way or in negotiation. These projects were selected in Rounds 1 and 2 of the program and together they have a value approaching $2.3 billion. Perhaps more importantly, they offer private cost-sharing amounting to $6 for every $4 of Federal funding.

We began Round 3 of the program in May, and, by the end of December, we anticipate selecting 15 to 20 additional projects to share in the $545 million of Federal funding. Our fiscal year 1990 budget request contains sufficient funding for this round and for the two final rounds of competition in 1990 and 1991.

The Clean Coal Program is certainly the most visible of our fossil energy related efforts, but it should not overshadow the importance of a sound, core level of research and development.

At first glance, Mr. Chairman, the fossil energy R&D budget appears to be a substantial reduction from the fiscal year 1989 appropriated level, but fully one-third of the difference can be attributed to four factors:

First, the Administration is not proposing to fund the MHD program. As in past years, the issue is not technical; it's affordability. For many years now, the government has borne by far the largest financial share of this program, well above the 90-percent level, and we simply cannot allocate this large amount of funding without seeing greater leveraging of our dollars through private or other types of cost-sharing.

Second, no funds are requested for phosphoric acid fuel cells. Development will still continue using prior year funds, and the private sector should be willing to take the lead in the final commercialization stage of this technology.

Third, our work at the Wilsonville and La Porte liquefaction facilities has achieved very successful milestones. When market conditions are right, industry should be well-positioned to move the concepts tested at these units into commercial use.

And fourth, we have completed our funding commitments for two construction projects at West Virginia University and the University of Oklahoma.

The other large construction items in last year's budget, the administration building at the Morgantown Energy Technology Center and at the Pittsburgh Energy Technology Center, are simply not affordable in times of budget constrain[illegible]s.

Within the $165 million R&D budget request, however, we retain several key elements.

We have a significant commitment to new technologies that can reduce acid rain-related pollutants. Roughly 70 percent of our coal R&D program is oriented toward these types of projects.

Many of the projects that would be continued in fiscal year 1990 could ultimately offer options that reduce the release of CO_2 compared to conventional coal technology. The issue of CO_2 emissions and global climate change is also an important issue that deserves sound scientific investigation. There are still many unknowns. However, while we await the outcome of ongoing research, it is important that we pursue future technological options. Highly efficient combustion technologies, new concepts in pollution control, and other innovative energy technologies can provide significant energy benefits while at the same time reducing CO_2 emissions and other suspect emissions. Many of those are included in our program.

We are also very cognizant of the liquids problem facing the country in the form of rising oil imports. So, just over a third of our R&D budget applies to technologies that can provide alternative sources of liquid fuels. From a percentage standpoint, that is greater than last year's budget request.

We have proposed several new initiatives to boost prospects for western coal. Our goal is to expand coal use in the West perhaps, for example, as a feedstock for the western railroad industry or as an export commodity to the Pacific Rim. We believe new technology offers some excellent opportunities to make full use of all of our coal resources, both in the East and the West.

And finally, we continue to place a great degree of emphasis on oil and gas research with a clear focus on transferring existing and emerging technologies to industry. Our geoscience program, in particular, has been strengthened and will continue to provide both financial and staff resources to ensure that the Nation's geoscience knowledge base is enhanced.

We have begun significant new efforts in both heavy and light oil recovery and our program now includes projects that can be of near term benefit, particularly to the marginal oil producer, including the stripper well operator, that is hurt each time there is a radical swing in oil prices. We have new projects underway in microbial enhanced recovery, as well as in the more traditional enhanced oil recovery processes.

In the gas area, we are assessing the results of a major field test in tight sands and Devonian shale, and we have begun an intense effort to examine the potential for secondary gas recovery. Our program is well coordinated with and complementary to the program of the Gas Research Institute.

In conclusion, Mr. Chairman, the budget we have presented is a solid budget. Every program it contains offers the Nation potentially significant energy and environmental benefits. The programs it does not contain are not necessarily bad programs. They were simply weighed against areas where government could best apply its funding. The projects that emerged from this balancing are those which we believe need Federal assistance the most or which, in turn, will return the most benefits for the investment of tax dollars.

Thank you, Mr. Chairman. That concludes my opening statement. I would be glad to answer any questions you have.

[The prepared statement of Mr. Wampler follows:]

The FY 1990 Fossil Energy Budget Request

Statement by J. Allen Wampler
Assistant Secretary for Fossil Energy
U.S. Department of Energy
to the
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
U.S. Senate

The Department of Energy's FY 1990 fossil energy budget request strikes a balance between the need for fiscal stringency and the need to sustain the momentum of programs that are producing cleaner, more efficient processes for the fuels that supply nearly 90 percent of our country's energy requirements.

Coal, oil and natural gas are the mainstays of our energy economy. Together, they supply directly two-thirds of the energy used by the industrial sector, one-third of the energy used by residential and commercial establishments, and virtually all of our transportation fuel requirements. As fuels for electric power generation, they account for approximately 70 percent of the electricity produced in this country which, in turn, is used by the other end-use sectors to produce much of the nation's goods and services.

Fossil fuels have contributed greatly to our standard of living. If we are to maintain and improve that standard in the foreseeable future, we must continue to look to these fuels as a fundamental component of our domestic energy industry. Our objective, therefore, must be to develop technologies that can ensure that fossil fuels can continue to be used without compromising our environmental or economic goals.

Recently, the potential conflicts between energy and environmental objectives have received heightened attention in debates over the consequences of acid rain and the release of so-called "greenhouse gases" from fossil fuel combustion. Scientific understanding of these problems is still far from complete, and the costs of overreaction could impose a staggering burden on the nation's future economic growth and prosperity.

In addition, new concerns have been raised about the future reliability of electric power capacity with reserve margins in some areas of the country having diminished at greater-than-expected rates. The nation's long-term competitiveness in international markets is also a matter of national concern, and how well we respond to our domestic environmental, economic and energy challenges will dictate, in large part, how fast – and to what extent – we are successful in restoring a more favorable balance of trade.

Consequently, if new technological solutions can be found that meet our environmental objectives, while at the same time being more cost effective and efficient than today's options, future policy decisions can be made in a manner that reflects both our social goals and our need to maintain a strong, energy secure nation.

The FY1990 Fossil Energy budget has been formulated with this objective in mind. The budget consists of two major components (with their FY 1990 funding requests).

- **The Clean Coal Technology Demonstration Program — $710.0 million**
- **The Fossil Energy Research and Development Program — $163.6 million.**

Clean Coal Technology Demonstration Program

The Clean Coal Technology Program is a government-industry, co-funded effort to demonstrate advanced concepts for using coal cleanly and more efficiently than today's technology. Begun by Congress in 1986 and expanded by President Reagan in 1987 (in response to recommendations from the U.S. and Canadian Special Envoys on Acid Rain), the program is expected to finance more than $5 billion of projects when completed in the 1990s, with at least half of the funding provided by the private sector.

(If the ratio of private to public cost-sharing experienced in the first two rounds of competition — approximately 60/40 — remains consistent for the entire program, the Clean Coal program would finance more than $6.25 billion of demonstration projects.)

In contrast to the more fundamental projects undertaken in the coal portion of the Fossil Energy Research and Development Program, the Clean Coal Technology Demonstration Program provides financial assistance for commercial scale or near-commercial scale ventures. By building and operating these first-of-a-kind plants, industry can obtain data on construction and operating costs, reliability, maintenance and other performance factors that are necessary to make commercial deployment decisions.

Program Status. To date, two rounds of competition have been completed, one in 1986, the other last year. The competitions have resulted in 29 projects with a total value estimated at nearly $2.3 billion. Eight of the projects have completed negotiations and are underway. (Another project which had been negotiated, *The Appalachian Project,* was discontinued on June 23, 1989, when the private sponsor could not acquire sufficient financial support or a host site to proceed with the integrated gasification combined cycle demonstration plant.) The eight ongoing projects are listed in the chart at the top of the next page.

Negotiated Clean Coal Technology Projects

Project	Industry	DOE	Total
Tidd PFBC Demonstration Project	$124,800,000	$60,200,000	$185,000,000
Advanced Cyclone Combustor Demonstration Project	$494,245	$490,149	$984,394
LIMB Demonstration Project	$11,807,914	$7,597,026	$19,404,940
Gas Reburning/Sorbent Injection Demonstration Project	$15,000,000	$14,998,253	$29,998,253
Underground Coal Gasification Demonstration Project	$101,390,176	$11,792,362	$113,182,538
Prototype Coal/Oil Coprocessing Demonstration Project	$180,674,805	$45,000,000	$225,674,805
Colorado-Ute Circulating AFB Demonstration Project	$34,167,000	$19,920,000	$54,087,000
TRW Advanced Slagging Combustor Demonstration Project	$25,480,000	$23,520,000	$49,000,000
TOTAL	$504,447,268	$183,517,790	$677,331,930

- The remaining 21 projects (5 selected in Round #1 and 16 selected in Round #2) are in negotiations with the Department.

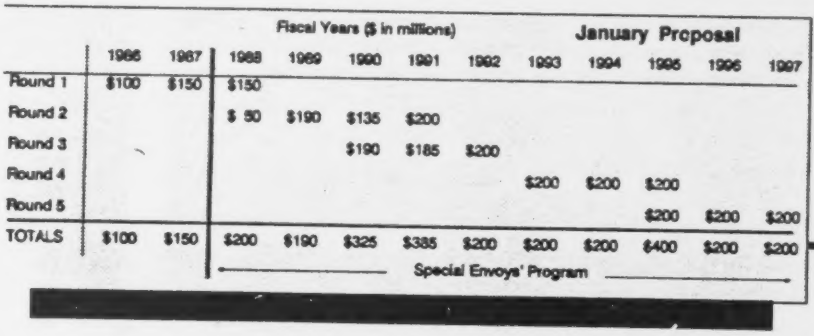
FY 1989 Congressional Budget Action. In FY 1989 budget action, Congress spread the appropriations to complete Round #2 ($525 million) over three years, providing $190 million in FY 1989, $135 million in FY 1990 and $200 million in FY 1991. The Congress also approved the Department's request for $575 million for FY 1990 to support a third round of competition.

FY 1990 Administration Budget Request. In its initial FY 1990 budget request (January 1989), the Department proposed to extend the $575 million previously appropriated for the third round of competition over three years (FY 1990-92) and to defer completion of funding for the full $2.5 billion program until FY 1997 (rather than the original completion date of FY1992).

On February 9, 1989, President Bush reinstated the original 5-year appropriations timetable of the program. In his budget message to Congress, the President said:

We must make use of clean coal. My budget contains full funding, on schedule, for the clean coal technology agreement that we've made with Canada. We've made that agreement with Canada and we intend to honor that agreement.

President Bush's revised budget would adhere to the previous Congressional appropriation of $575 million in FY 1990 for a third round of competition (due to begin in May), plus $135 million previously earmarked for the second round of competition. The President is also requesting Congress to appropriate the remaining $1.2 billion to complete the $2.5 billion (federal share) recommended by the U.S.-Canadian Special Envoys on Acid Rain. This funding – $600 million in each of fiscal years 1991 and 1992 – would be used as the federal share of projects selected in the final two solicitations



Revised (Bush) Proposal

	Fiscal Years ($ in millions)						
	1986	1987	1988	1989	1990	1991	1992
Round 1	$100	$150	$150				
Round 2			$ 50	$190	$135	$200	
Round 3					$575		
Round 4						$600	
Round 5							$600
TOTALS	$100	$150	$200	$190	$710	$800	$600
			Special Envoys' Program				

The proposed funding schedule (along with the prior FY1990 proposal) is shown in the following chart:

The Importance of Full Appropriations. President Bush has emphasized that the Clean Coal Technology Program is an integral part of his commitment to cleaner air and protection of the environment. The President has also stated his commitment to ending the long debate on acid rain through a program to obtain significant reductions of acid rain precursor pollutants by a specific date.

If the Clean Coal Technology Program is to provide the U.S. with new, more cost-effective options to meet the President's environmental goals, it is important for Congress to approve advance appropriations for the $1.2 billion required to complete the program.

By appropriating in advance funds for the remaining rounds of competition, Congress can send a strong message to industry that the government's commitment to clean coal technology remains intact and that research projects now in the development stage should be continued so that they can be considered for future support. If industry has confidence that such cost-sharing will be available for the final pre-commercialization step, it will have a greater incentive to contribute its own funds to the development of new, more innovative concepts.

The result would be:

- more industry cost-sharing at earlier stages of development, thereby permitting greater leveraging of federal research funds, and
- the evolution of better, more effective technologies as candidates for joint demonstration funding and ultimately, for commercial replication and deployment.

Congress would continue to help shape the future course of the program through its oversight and annual appropriations process. The Department would continue to adhere to Congressional guidance, and the opportunity would continue to exist for modifying criteria and other guidelines for future rounds of competition to reflect lessons learned and, if necessary, to incorporate new considerations or priorities.

Fossil Energy Research and Development Program

In contrast to the Clean Coal Technology Demonstration Program, the Fossil Energy Research and Development Program is oriented toward the earlier stages of the development process – i.e., the basic and applied research stages through the early stages of process engineering. For the most part, the technologies pursued are longer-range and higher-risk, but if successfully developed, could offer potentially greater benefits in terms of economics, efficiencies and/or effectiveness. The program is comprised of coal, petroleum, natural gas and several policy and management functions. Also, in FY 1990, a new line item has been added for *environmental restoration*.

- **The FY 1990 budget request is consistent with the FY 1989 request.**

The FY 1990 budget request, while well below the FY 1989 enacted level, is consistent with last year's request. The proposed funding reflects an appreciation of the need to limit federal spending and to concentrate available federal funds on high-risk, high-potential projects which industry cannot be expected to finance on its own.

The differences between the FY 1990 request and the funding levels appropriated by Congress for FY 1989 are governed primarily by the need for fiscal restraint. However, fully one-third of the difference between the FY 1989 appropriation and the FY 1990 request – or $73 million out of a difference of $217 million – can be attributed solely to four factors:

- The Administration is not proposing to continue the magnetohydrodynamics (MHD) program funded in FY 1989 at $37 million.
- The development of the phosphoric acid fuel cell concept has progressed to the point where any further federal involvement can be funded with previously appropriated funds; in FY 1989, phosphoric acid fuel cell funding amounted to $9.5 million.
- Work successfully concludes this year at the Wilsonville (AL) and LaPorte (TX) coal liquefaction test facilities. Significant advances have been achieved and a substantial data base now is in place. Industry is in the position to commercialize these technologies when market conditions are appropriate. Completion of work at these facilities will permit a reduction of $8.4 million from the FY 1989 appropriations.
- The Administration has completed its funding commitments for Congressionally added construction projects at West Virginia University and the University of Oklahoma. It cannot support continued funding for construction of administrative office buildings at the Morgantown and Pittsburgh Energy Technology Centers in these times of budgetary constraint. These projects accounted for $18.25 million in the FY 1989 budget.

A comparison of the FY 1989 and FY 1990 budgets is shown in the following chart:

Fossil Energy R&D Budget

Coal

	FY1989 Request	FY1989 Approp	FY 1990 Request
Control Tech. & Coal Preparation	$ 31.49	$ 48.93	$ 32.26
Adv. Research & Technology Devel.	21.41	25.56	25.54
Coal Liquefaction	10.30	32.39	9.66
Combustion Systems	17.42	26.70	15.76
Fuel Cells	6.63	26.53	6.50
Heat Engines	9.00	22.83	8.92
Underground Coal Gasification	0.27	1.37	0.43
MHD	0	37.00	0
Surface Coal Gasification	5.03	21.56	8.74
Subtotal, Coal	$101.55	$242.87	$107.81

Oil

	FY1989 Request	FY1989 Approp	FY1990 Request
Advanced Extraction & Process Tech.	$ 2.17	$ 4.20	$ 4.62
Enhanced Oil Rec.	16.98	23.58	18.24
Oil Shale	1.04	10.53	1.68
Subtotal, Oil	$ 20.19	$ 38.31	$ 24.54

Gas

	FY 1989 Request	FY 1989 Approp	FY 1990 Request
Eastern Gas Shales	$ 0.33	$ 3.08	$ 0.32
Western Tight Sands	0.32	3.32	0.32
Environmental & Advanced Research	1.08	4.98	3.43
Subtotal	$ 1.73	$ 11.38	$ 4.07

Other

	FY 1989 Request	FY 1989 Approp	FY 199 Request
Program Direction & Mgm't Support	$ 35.03	67.28	25.84
Plant & Capital Equipment	0.50	21.75	1.90
Cooperative Ventures	9.00	–	–
Environmental Restoration	–	–	1.04
Subtotal, Other	44.53	89.03	28.78

Totals

	FY 1989 Request	FY 1989 Approp	FY 1990 Request
Coal	$101.55	$242.87	$107.81
Oil	20.19	38.31	24.54
Gas	1.73	11.38	4.07
Other	44.53	89.03	28.78
TOTAL, FE R&D	$ 168.00	$381.59	$165.20

Note: All amounts are Budget Authority dollars in millions

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- **The FY 1990 budget request continues high priority research in acid rain and CO_2 mitigation technologies, and in the production of alternative liquid fuels, as well as new initiatives in western coal research.**

Even given the reductions from the FY 1989 appropriations, the FY 1990 Fossil Energy budget request offers the nation a viable research and development program that incorporates both new initiatives and continued priority given to pressing national concerns. For example:

Acid Rain-Related Funding. There is a continued emphasis on technologies that can reduce the release of pollutants associated with acid rain. As the chart on the next page shows, **research and development** of technologies that can have a direct impact on reducing acid rain-causing pollutants accounts for $76.5 million, or roughly 70 percent of the proposed coal research and development program.

The United States has achieved an excellent record of environmental progress. Since passage of the Clean Air Act in 1970, U.S. industry has spent nearly $250 billion to control air emissions. As much as $70 billion of this has been spent by the nation's coal-burning utilities to reduce sulfur dioxide (SO_2) emissions alone. Because of this investment, the nation's air is cleaner today than at any time in the last decade. SO_2 emissions from all sources have dropped 28 percent from their peak in 1973, while at the same time, coal use has increased by nearly 80 percent. New pollution control technologies, many of which will have their origins in the federal R&D program, will lead to further reductions in acid rain-causing pollutants.

The Administration will ask Congress to establish an acid rain program that will obtain significant SO_2 and NO_x emission reductions by specified dates. Much of the basis for this program will come from:

1) an intensive, 10-year, multi-agency effort to understand better the scientific causes and effects of acid precipitation. This effort is termed the National Acid Precipitation Assessment Program;

2) a *parallel* effort to develop new technologies that can expand the menu of available options for continuing or, if necessary, accelerating the reduction of acid rain-causing pollutants, and

3) identification of incentives that can be provided or disincentives that can be removed to ensure early deployment of better emission control technologies.

Most of the acid rain-related funding in this budget request is oriented toward the second element of the Administration's acid rain response. As the chart on the next page shows, the funding levels represent a significant national commitment to more economical and effective pollution control methods for the 1990s and 21st Century.

Acid Rain-Related Funding

FY 1989-1990
FOSSIL ENERGY BUDGET

COAL

	FY89 Request	FY89 Approps	FY90 Request
Control Technology & Coal Preparation	$31.49	$48.83	$32.26
Adv. Research & Technology Devel.	21.41	25.56	25.54
Coal Liquefaction	10.30	32.39	9.66
Combustion Sys.	17.42	26.70	15.76
Fuel Cells	6.63	26.53	6.50
Heat Engines	9.00	22.83	8.92
Underground Coal Gasification	0.27	1.37	0.43
MHD	0	37.00	0
Surface Coal Gasification	5.03	21.56	8.74
TOTAL, COAL	$101.55	$242.87	$107.81

Acid Rain Related Subactivities	FY89 Req.	FY89 App.	FY90 Req.
Adv. Research	$1.77	$1.77	$1.87
Coal Preparation	9.96	17.88	11.32
Flue Gas Cleanup	12.76	16.38	11.40
Gas Stream Cleanup	5.41	11.57	4.56
Waste Management	1.40	1.52	3.09
Coal Utilization Science	$3.05	$3.69	$3.50
NAPAP Activities	0.75	0.97	0.82
Adv. Research	$ 2.09	$2.97	$1.14
AFB Combustion	1.74	2.74	1.65
PFB Combustion	7.12	9.27	6.63
Adv. Combustors	2.68	6.20	2.63
Alternate Fuels	3.79	5.52	3.71
Fuel Cells	$ 6.63	$26.53	$ 6.50
Heat Engines	$ 9.00	$22.83	$ 8.92
MHD	0	$37.00	0
Surface Coal Gas.	$ 5.03	$21.56	$ 8.74
Subtotal, Acid Rain Related	$73.17	$188.20	$76.50

Clean Coal Technology

FY 1989 Request	FY 1989 Approps	FY 1990 Request
$190.00	$190.00	$710.00

CO_2 Mitigation Technologies. Many of the technologies being developed in the Fossil Energy program can have a positive impact on the reduction of so-called "greenhouse gases" such as carbon dioxide (CO_2).

The question of whether the earth is warming because of the accumulation of so-called "greenhouse gases" is a matter of debate and conflicting scientific analysis. Moreover, there remain significant questions about the relative contributions of various human activities -- for example, fossil fuel combustion versus global deforestation -- and the relative effectiveness of policy actions taken by any single nation, even one as large as the U.S., to control or reduce such emissions. For example, U.S. coal combustion contributes to less than eight percent of the total worldwide release of CO_2, and in both the U.S. and western Europe, there has been little growth in CO_2 emissions since the 1970s.

Nevertheless, if the scientific evidence ultimately shows that actions are necessary to mitigate global climate change, technology modernization can keep us from having to resort to regulation -- and the usual stagnation caused by regulatory approaches.

The FY 1990 Fossil Energy budget contains several programs designed to develop modernized coal technologies with increased efficiencies over present processes, which could thereby reduce all combustion emissions, including carbon dioxide, per unit of energy produced. For example:

- Advanced coal technologies, such as pressurized fluidized bed technology and gasification-combined cycle, that offer power generation efficiencies in the 40-45 percent range (compared to 30-35 percent for conventional plants) can reduce CO_2 emissions by 10-15 percent.
- New flue gas cleanup and other pollution control methods that don't force overall reductions in power plant efficiency (such as is the case with today's scrubber technology) can be used to reduce other pollutants without adding to the amount of CO_2 released per unit of energy.

In addition, research into new recovery techniques for unconventional gas can ensure that the nation continues to have long-term supplies of natural gas, which emits about one-half as much CO_2 as coal per unit of energy produced.

. The requested Fossil Energy funding that applies to these CO_2-mitigating technologies is shown by the chart on the next page.

CO_2-Related Funding

FY 1989-1990 FOSSIL ENERGY BUDGET

COAL

	FY89 Request	FY89 Approp	FY90 Request
Control Technology & Coal Preparation	$31.49	$48.93	$32.28
Adv. Research & Technology Devel.	21.41	25.56	25.54
Coal Liquefaction	10.39	32.39	9.66
Combustion Sys.	17.42	26.70	15.76
Fuel Cells	6.63	26.53	6.50
Heat Engines	9.00	22.83	8.92
Underground Coal Gasification	0.27	1.37	0.43
MHD	0	37.00	0
Surface Coal Gasification	5.03	21.56	8.74
TOTAL, COAL	$101.55	$242.87	$107.81

CO_2-Related Subactivities	FY89 Req.	FY89 Approp.	FY90 Req.
Adv. Research	$1.77	$1.77	$1.87
Coal Preparation	9.95	17.88	11.32
Flue Gas Cleanup	12.96	16.38	11.40
Gas Stream Cleanup	5.41	11.57	4.58
Coal Utilization Science	$3.05	$3.89	$3.50
Adv. Research	$2.09	$2.97	$1.14
AFB Combustion	1.74	2.74	1.85
PFB Combustion	7.12	9.27	6.63
Adv. Combustors	2.88	6.20	2.63
Fuel Cells	$6.63	$26.53	$6.50
Gas Turbines	$6.63	$13.06	$6.56
MHD	0	$37.00	0
Systems for Power Production	$.88	$5.93	$1.20
Subtotal, CO_2 Related Coal	$61.11	$154.81	$58.98

Gas	$1.73	$11.38	$4.07
Unconventional Gas Recovery	$1.73	$11.38	$4.07

Clean Coal Technology

Relevant Projects	Industry	DOE	Total
Tidd PFBC Plant	$107.3M	$60.2M	$167.5M
Colorado-Ute AFBC Plant	$34.2 M	$19.9M	$54.1M

Alternative liquid fuels. The FY 1990 budget funds several programs designed to increase options for liquid fuels. With U.S. oil imports rising beyond the 40 percent mark (of total oil consumption), the most pressing national energy need is to ensure that we maintain an adequate and secure supply of liquid fuels.

As the chart on the next page shows, the FY 1990 Fossil Energy budget request contains $56.84 million for projects that can expand our liquid fuel options. This represents 34 percent of the total Fossil Energy R&D budget request. (For comparison, the FY 1989 budget request contained $39.65 million for liquids-related research, or approximately 24 percent of the total R&D budget request.)

In addition, as the chart indicates, two of the Round #1 Clean Coal Technology projects, with a total estimated value of more than $295 million, can contribute directly to increasing our domestic supply of liquid fuels.

Western coal initiatives. The FY 1990 budget contains several initiatives that can boost prospects for increasing the use of coal in the West and for increasing U.S. western coal export opportunities.

The U.S. has several hundred years of coal supply in deposits found throughout the country. Eastern coals, primarily bituminous and anthracite coals, today represent 70 percent of all coal mined in the U.S. and 90 percent of all coals exported. Much of the Department's coal-related budget is aimed at increasing the attractiveness – particularly from an environmental standpoint – of using eastern coals.

Western coals – subbituminous coals and lignites – are naturally low in sulfur content, yet suffer from low heating values because of their high ash and moisture content. Their high alkali content also can lead to boiler fouling and increased plant operating costs. Yet, these coals represent more than half of the demonstrated U.S. coal reserve base and offer the potential for meeting increasing demands for power in the western region of the U.S. as well as in burgeoning overseas markets along the Pacific Rim and elsewhere.

In the FY 1990 budget, the Department has included several initiatives intended to bring the knowledge base for western coals up to the same level as that of eastern coals. Two strategies are being pursued:

1) to develop technologies that could help expand coal use in the West. For example, one initiative in the FY 1990 budget request would study the use of western coals in diesel engines, which could help reduce the Western railroad industry's use of imported oil. Another initiative would involve the study of special wastewater treatment techniques and reflects the need to understand better the unique aspects of dealing with chemical constituents that differ considerably from those of eastern coals. Additionally, efforts are underway in mild

Liquids Funding

Liquids from Coal

FY 1989	Request Amount	Request % of Total Request	Approps
Liquefaction	7.06	4.20%	25.49
Gasification	.83	0.49%	11.59
Coal Slurries (Alt. Fuels/Coal Prep.)	13.74	8.18%	23.20
AR&TD			
Bioprocessing	0	0%	1.02
Liquefaction	0	0%	6.90
Surface Coal Gas.	0	0%	2.68
Subtotal (from coal)	$21.63	12.87%	$70.88

FY 1990 Request	Amount	% of Total Request
Liquefaction	$6.56	3.97%
Gasification	6.04	3.66%
Coal Slurries (Alt. Fuels/Coal Prep.)	$15.03	9.10%
AR&TD		
Bioprocessing	.21	0.13%
Liquefaction	3.10	1.88%
Surface Gas.	.65	0.39%
Subtotal	$31.59	19.13%

Other Liquids

Enhanced Oil Rec.	$16.98	10.11%	$23.58
Oil Shale	1.04	0.62%	10.53
AE&PT	0	0%	4.20
UGR (Gas to Liquids)	0	0%	1.21
Subtotal (Other)	$18.02	10.73%	$39.52

EOR	18.24	11.04%
Oil Shale	1.68	1.02%
AE&PT	4.62	2.80%
UGR (Gas to Liquids)	0.35	0.21%
Subtotal	24.89	15.07%

Total liquids	**$39.65**	**23.60%**	**$110.40**	**$56.48**	**34.20%**
(FE R&D Request: $ 166.00)				(FE R&D Request: $165.21)	

Clean Coal Technology

	TOTAL	DOE	INDUSTRY
Ohio-Ontario Coal Oil Co-Processing	$225.67	$45.00	$189.67
Energy Int. Underground Coal Gasification	$ 70.12	11.79	58.32
Subtotal (Clean Coal Tech. Liquids)	$295.79	$56.79	$247.99

gasification, which could convert western coals to more valuable liquid, gaseous and solid fuels; and

2) to accelerate efforts to open new markets for western coals internationally, especially in the Pacific region. This would be implemented by providing U.S. coal producers and technology developers with information they can use to market their products abroad, as well as by attempting to link advanced coal drying and mild gasification processes to the export of western coals. DOE will also begin consultations with industry to determine if an appropriate role exists for the government in the research and development of coal transportation alternatives for western coals.

- **The FY 1990 budget continues support for oil and gas research with an emphasis on technology transfer to the independent producer.**

The FY 1990 fossil energy budget also maintains funding for vital research that can extend our domestic supplies of petroleum and natural gas. The U.S. has roughly 300 billion barrels of oil in known reservoirs that cannot be recovered with currently available technology at today's energy prices. This massive energy resource – more than 10 times the currently producible U.S. oil reserves – will require a better understanding of reservoir geology and fluid movement as well as the development of new, innovative recovery techniques. Significant potential also exists for *secondary gas recovery*, i.e., the production of natural gas that may have been bypassed or missed by conventional production techniques. The FY 1990 budget request contains funding to pursue both of these untapped hydrocarbon resources, as the following describes:

Petroleum. The FY 1990 petroleum-related budget, contained in two line items *Advanced Exploratory and Process Technology* and *Enhanced Oil Recovery*, continues to implement many of the research priorities outlined in the Department's "Enhanced Oil Recovery (EOR) Initiative" published last year after wide consultation with industry, state and academic petroleum experts.

As the "Enhanced Oil Recovery Initiative" described, the currently unrecoverable oil resource in the U.S. is made up not only of traditional EOR targets (i.e., *immobile* oil resources that require the injection of heat, gases or chemicals to move oil through the reservoir) but also significantly large supplies of *mobile* oil resources that may have been bypassed because oil reservoirs are not homogeneous. These mobile oil resources, existing in subtle traps or "reservoir envelopes" or otherwise isolated by barriers to fluid flow, may not require extensive EOR measures. Instead, a better understanding of the reservoir geology can lead to more predictable improvements in conventional primary and secondary recovery operations.

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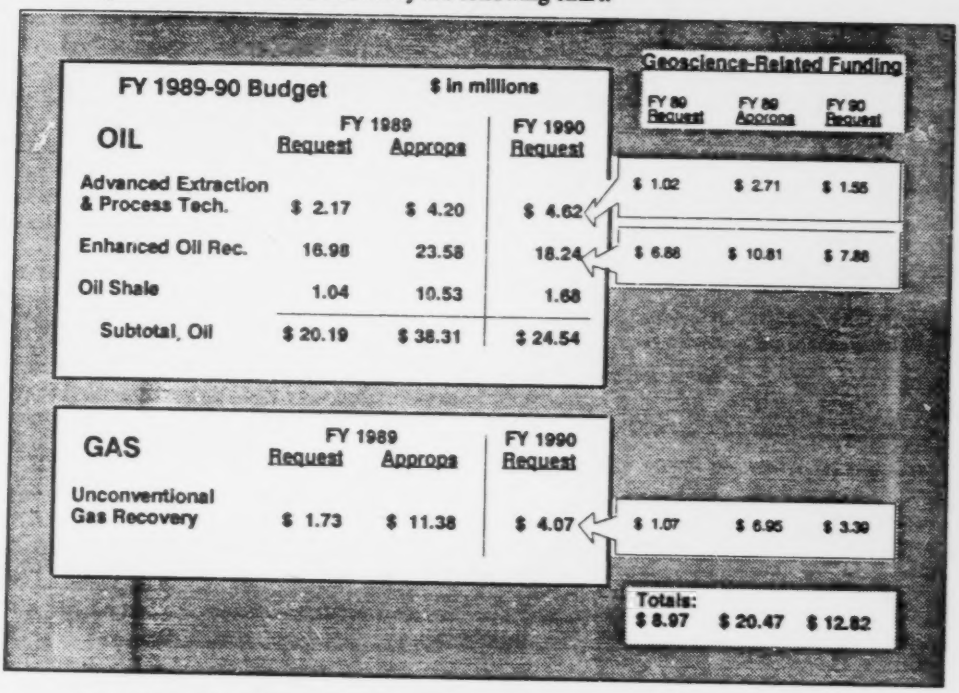
Therefore the FY 1990 budget places a substantial emphasis on geoscience-related research. DOE has also encouraged the formation of geoscience-oriented consortia involving university, state agency and private organizations. While the geoscience projects are managed and conducted as an inherent part of the petroleum and gas programs, they are overseen by a newly-created Office of Geoscience Research, reporting directly to the Assistant Secretary for Fossil Energy. The geoscience-related funding for oil and gas related research is shown by the following chart:



Complementing the more fundamental geoscience research, the Department's FY 1990 petroleum budget also includes funding for both heavy and light oil recovery techniques. In the heavy oil program, research would continue on ways to increase the sweep efficiency of steamfloods and on new techniques for alkaline flooding. Novel extraction methods for presently unrecoverable heavy oil resources would be explored, as would advanced methods for restimulating mature wells, conducting oxygen-fueled firefloods, and injecting heat more efficiently into heavy reservoirs. Cooperative efforts with Venezuela in reservoir characterization also would receive funding in FY 1990.

In the light oil program, a wide range of both in-house and cost-shared research would take place to improve current CO_2-injection techniques, including a study of the merits of using CO_2 mobility control concepts on the North Slope of Alaska.

Also in the light oil research program, laboratory and field tests would continue in the area of microbial enhanced oil recovery, including a newly commissioned field test to be conducted in conjunction with the University of Oklahoma.

To assist in carrying out many of the petroleum-related programs, the Department has also established a site office in Metairie, Louisiana. The new office will serve as the focus of hydrocarbon research and development programs for the southeastern region of the U.S. The director and initial staff of this office are now in place.

Gas-Related Research. The Department is also proposing funding to conduct high-priority gas-related research projects. With major field experiments now completed in programs involving tight sand formations in the West and eastern gas shales in the East, the largest proportion of gas-related research is being directed toward an intense study of *secondary gas recovery.* A DOE-sponsored study last year, conducted by a panel of gas experts, identified enough natural gas in the lower-48 states to meet current demand for 35 years at costs below $3.00 per thousand cubic feet. Of the nearly 600 trillion cubic feet of gas estimated by the panel to be in this cost range, nearly 60 trillion cubic feet was included in the secondary gas category; that is, gas in bypassed reservoirs, in untapped compartments, or in deep pools that could have been missed by conventional production method. Last year, DOE provided a grant to the University of Texas Bureau of Economic Geology to verify the existence of this gas and the best means for producing it.

The Department has oriented its gas research program to complement the efforts sponsored by the Gas Research Institute (GRI), the privately-supported research arm of the gas industry. GRI, for example, will manage the secondary gas recovery project. In all, GRI will finance more than $170 million of gas-related research this year.

Technology Transfer. The budget request reflects a major emphasis on establishing mechanisms for transferring the results of federally-sponsored research to the private sector. Special emphasis has been given to negotiating cooperative exchange agreements with state governments (13 such agreements are now in place), both as a way of leveraging federal research funds and providing a mechanism for transferring the results of federally-sponsored research to the private sector. In the oil program, specific initiatives have been undertaken to transfer technology especially to the 24,000 independent oil producers who conduct virtually no research themselves. Particular emphasis in this area involves cooperative efforts through the Interstate Oil Compact Commission, the Western Research Institute and the national laboratories (the latter involving the transfer of unclassified, defense-related technology for use in locating and recovering oil and gas supplies).

More detailed information on each of the Fossil Energy research and development activities is included in the following program fact sheets.

COAL RESEARCH AND DEVELOPMENT

Control Technology and Coal Preparation

Funding Activities	Dollars in Millions FY 1988	FY1989	FY1990
Advanced research	$ 2.0	$ 1.8	$ 1.9
Coal Preparation	15.8	17.7	11.3
Flue Gas Cleanup	14.5	16.4	11.4
Gas Stream Cleanup	9.9	11.5	4.6
Waste Management	1.4	1.5	3.1
Total	$ 43.6	$ 48.9	$ 32.3

Background

- **Advanced Research**, generic and fundamental in nature, is conducted on processes used to separate constituents such as sulfur and nitrogen oxides in coal fuel streams before, during and after combustion.
- **Coal Preparation** is directed toward the development of advanced coal cleaning technologies that will reduce the ash and sulfur content of U.S. coal so that the product can be formulated into a high quality fuel that could replace oil and/or gas and reduce environmental emissions of suspected acid rain precursors from coal-fired power plants in both new and retrofit applications. Research is conducted in three broad areas: (1) physical treatment and cleaning; (2) chemical/biological pretreatment and cleaning; and (3) engineering support and ancillary operations.
- **Flue Gas Cleanup** addresses the removal of polluting contaminants from fossil fuel fired systems to meet current and projected environmental standards that inhibit the utilization of fossil fuels. Efforts focus on fundamental research of processes for the combined removal of NO_x, SO_x and particulates, both for utility and industrial applications.
- **Gas Stream Cleanup** includes the technology for removal of contaminants from gasifier and combustor process streams prior to utilization in coal conversion systems. Both hardware and environmental protection are key concerns. Applications include PFB combustors, integrated gasifier combined cycle (IGCC) turbines, direct coal-fired turbines, coal-fueled diesels, and liquid fuel production.
- **Waste Management** focuses primarily on waste sampling and characterization from coal preparation and emerging technology wastes.

FY 1990 BUDGET	Dollars in Millions
• **Advanced Research**	
– Increase generic research on acid rain precursors and their removal. Examine the surface properties of coal and coal minerals. Continue studies of SO_x/NO_x separation processes and the effects of process filtration processes. (FY 1989 - $1.8M)	$1.9
• **Coal Preparation**	
– Initiate western coal drying research. (FY 1989 - $0)	0.5
– Continue research and explore new concepts for physical and chemical/biochemical coal cleaning. Continue research on technologies for controlling emissions from pre-NSPS utility boilers. (FY 1989 - $8.3M)	5.9
– Continue DOE/EPRI testing of most promising advanced concepts for fine coal cleaning. (FY 1989 - $2.2M)	0.5
– Continue high sulfur coal research program with the State of Illinois. (FY 1989 - $1.5M)	1.5
– Continue in-house research to investigate and evaluate advanced physical and chemical coal cleaning concepts. Continue organic sulfur chemistry studies. Characterize feedcoal and coal cleaning products, and study the role of surface functional groups in coal treatment. Continue program management support. (FY 1989 - $3.0M)	2.9
• **Flue Gas Cleanup**	
– Continue research for TUNG scrubbing process. Participate in EPRI program of emissions control for electric power generating stations burning high-sulfur coals. Continue spray dryer and in-duct technology development and systems integration studies for low cost duct injection. (FY 1989 - $5.8M)	4.6
– For combined NO_x/SO_x control, continue advanced NO_x/SO_x chemistry research, systems modeling, and economic evaluation. Continue development of advanced separation, evaluation of the moving-bed cop-	5.0

FY 1990 Budget (con'd)	Dollars in Millions
per oxide process, and large scale development of NO_x/SO_x processes. (FY 1989 - $7.4M)	
– Continue advanced NO_x control research, larger scale tests of fine particulate control in coal-fired boilers, research on emissions control from small scale boilers, and provide for technical and program management support. (FY 1989 - $2.4M)	1.8
• **Gas Stream Cleanup**	
– For Integrated Gasification Combined Cycle, continue development of novel sorbents and sorbent reactors. Commission a desulfurization system for a gasifier test facility. (FY 1989 - $3.8M)	1.8
– For Direct Coal-Fired Turbines, continue development of acoustic agglomeration, sulfur/particulate removal, and integrated low emissions concepts. Design cleanup equipment for METC combustor. (FY 1989 - $2.2M)	1.7
– Conduct systems analysis, membrane development, and program management support. (FY 1989 - $2.3M)	1.1
• **Waste Management**	
– Conduct wastewater treatment R&D for western coal processing. (FY 1989 - $0)	1.9
– Continue multi-site field monitoring of disposed wastes; geochemical and geotechnical analysis of wastes; characterization of wastes; waste-related data base maintenance; and program management support. (FY 1989 - $1.4M)	1.2
Total, Control Technology and Coal Preparation	**$ 32.3**

Advanced Research and Technology Development

Funding Activities	Dollars in Millions FY 1988	FY1989	FY1990
Coal Utilization Science	$ 4.5	$ 3.7	$ 3.5
Materials & Components	8.5	8.5	6.4
Technology Crosscut			
Environmental Activities	2.4	2.6	2.5
Technical & Economic Analyses	1.5	2.0	2.7
Exploratory Tech. Base Res.	0.0	0.0	2.4
Coal Technology Export	0.0	0.0	2.4
International Program Support	0.0	0.8	0.7
Instrumentation & Diagnostics	1.5	1.5	1.3
Bioprocessing of Coal	1.0	1.0	0.2
University Coal Research	5.5	5.5	3.8
Total	$ 24.9	$ 25.6	$25.6

Numbers may not add due to rounding

Background

- The Advanced Research and Technology Development (AR&TD) Program is directed toward removing the inherent scientific and engineering barriers in generic technical areas that may hinder the development of all fossil energy technologies.
- The coal science program focuses on mission-oriented fundamental research which will lead to coal utilization systems that offer substantial improvements in efficiency, reliability and environmental performance.
- The AR&TD program includes generic studies of materials and components, investigations of instrumentation concepts in environments associated with advanced coal technologies, and exploratory research with high payoff potential for major advances to enhance greater use of coal in the U.S.
- The technology crosscut program undertakes management and scientific studies and research relating to several crosscutting areas relating to fossil fuel technologies.

FY 1990 Budget	Dollars in millions
• Coal Utilization Science	
– Continue generic studies of coal properties and the underlying chemistry and physics of coal utilization	$ 3.5

FY 1990 Budget (con'd)

	Dollars in Millions
processes. Includes research on surface science pertaining to coal beneficiation; combustion science pertinent to boilers, heaters, heat engines, gas turbines and fluidized beds; separation science pertinent to SO_x/NO_x, particulate and trace element pollutant removal; and waste characterization. Continue to fund technical and program management support. (FY 1989 - $3.7M)	
• **Materials**	
– Continue research on structural ceramic composites, microwave sintering, advanced austenitic alloys, advanced aluminides, ceramic membranes, ceramic catalyst supports, mechanisms of erosion and corrosion, solid oxide fuel cell materials, and studies of the formation and breakdown of protective oxide scales. Continue to fund technical and program management support. (FY 1989 - $6.5M)	5.0
• **Components**	
– Continue activities to develop novel components for advanced coal technologies, fundamental research on solids transport, and continue to fund technical and program management support. (FY 1989 - $2.0M)	1.4
• **Environmental Activities**	
– Continue analyses of issues associated with air and water quality, solid waste disposal, and toxic substances. Continue support of occupational health, quality assurance, and safety compliances services. Continue research conducted under NAPAP with emphasis on quality assurance of data and analytical tools. (FY 1989 - $2.5M)	2.5
• **Technical & Economic Analyses**	
– Continue generic studies supporting multi-year planning, FE strategy and program formulation; conduct contract studies that crosscut a number of FE programs, fund IEA/Coal Research Service activities. (FY 1989 - $2.0M)	2.7

FY 1990 Budget (con'd)	Dollars in Millions
• Exploratory Technology Base Research	
– Fund joint government-industry cost-shared research at Western Research Institute and the University of North Dakota Energy and Minerals Research Center (FY 1989 - $0.0M)	2.4
• International Program Support	
– Conduct analyses, studies and technical evaluations of the IEA and bilateral agreement activities in which the FE program is involved and provide technical and logistic support for international collaborative fossil energy research. (FY 1989 - $0.8M)	0.7
• Coal Technology Export	
– Provide support for coal technology export and linkage studies, coal and coal technology programs and promotion initiatives, Less Developed Countries Coal/Technology Export project identification, prefeasibility and project initiatives, and U.S./Italy project on Superclean Coal Water Slurries. (FY 1989 - $0.0M)	2.1
• Instrumentation and Diagnostics	
– Investigate in-situ instruments and develop spectroscopic techniques to identify molecular species and to provide process control in hot gas streams. Characterize coal liquid slurry atomization and develop novel viscosity measurement methods for coal slurry based combustion systems. Investigate fiber optics technology, explore instrumentation techniques for densely loaded streams, provide crosscutting instrumentation system information, and fund technical and management support. (FY 1989 - $1.5M)	1.3
• Bioprocessing of Coal	
– Continue, at a reduced level of effort, research on bioprocessing of coal with emphasis on fundamental mechanisms of desulfurization and provide technical and management support. (FY 1989 - $1.0M)	0.2

FY 1990 Budget (con'd)

	Dollars in Millions
• **University Coal Research**	
– Support approximately 22 new grants at universities on the ongoing research topics including coal science, reaction chemistry, surface science, advanced process concepts, thermodynamics, engineering fundamentals, and environmental sciences; continue encouragement of collaboration between university and industrial researchers. Provide for technical and management support. (FY 1989 - $5.5M)	3.8
Total, Advanced Research and Technology Development	$25.6

Coal Liquefaction

Funding Activities	Dollars in Millions FY 1988	FY1989	FY1990
Advanced Research	$ 6.1	$ 6.9	$ 3.1
Direct Liquefaction	13.4	17.3	2.9
Indirect Liquefaction	6.6	6.6	2.7
Support Studies/Engineering Evaluations	1.0	1.6	1.0
TOTAL	$27.1	$32.4	$9.7

Background

- This program supports basic and applied research to develop advanced technology for the production of synthetic liquid fuels from coal. The Department focuses upon two approaches to produce liquid fuels from coal, direct liquefaction and indirect liquefaction.

FY 1990 Budget

	Dollars in Millions
• **Advanced Research**	
– Continue research on: novel catalytic, biological and other approaches to coal liquefaction; improving the understanding of liquefaction processes; and, on	$ 3.1

FY 1990 Budget (con'd)	Dollars in Millions
physical, chemical and thermodynamic properties of fossil fuel liquids. Continue to fund technical and program management support. (FY 1989 - $6.9M)	
• **Indirect Liquefaction**	
– Continue laboratory research at PETC investigating catalysts/reactor systems to efficiently convert coal derived gaseous feedstocks to gasoline, diesel, or jet fuels. Maintain limited laboratory research with industry and universities on alcohol and hydrocarbon fuel process concepts. (FY 1989 - $6.6M)	2.7
• **Direct Liquefaction**	
– Continue PETC in-house research. Continue laboratory research in co-processing. Maintain limited research on staged catalytic liquefaction. (FY 1989 - $17.3M)	2.9
• **Support Studies/Engineering Evaluations**	
– Maintain process stream characterization research for advanced coal liquefaction and co-processing processes. Continue novel catalyst development and process studies at Sandia National Lab. (FY 1989 - $1.6M)	1.0
Total, Coal Liquefaction	$ 9.7

Combustion Systems

Funding Activities	FY 1988	FY1989	FY1990
Advanced Research	$ 3.4	$ 3.0	$ 1.2
Atmospheric Fluidized Bed	2.4	2.7	1.7
Pressurized Fluidized Bed	7.2	9.3	6.6
Advanced Combustion Tech.	3.5	6.2	2.6
Alternative Fuels Utilization	3.7	5.5	3.7
Limestone Injection Multi-Stage Burners	5.0	0.0	0.0
TOTAL	$25.2	$26.7	$15.8

Background

- The Department of Energy has developed a program to increase the contribution and application of the nation's coal resources through the development of acceptable combustion systems and fossil-derived fuels for the marketplace. The programs within the overall Combustion Systems activity are: Advanced Research, Atmospheric Fluidized Bed, Pressurized Fluidized Bed, Alternative Fuels and Advanced Combustion Technology. Funding for the LIMB program, conducted by EPA, was also part of this activity.

FY 1990 Budget	Dollars in Millions
Advanced Research	
– Continue generic studies to examine the fundamental aspects of combustion mechanisms, engine combustion design, corrosive behavior and deposition of combustion products. (FY 1989 - $3.0M)	$ 1.2
Atmospheric Fluidized Bed Combustion	
– Continue to conduct in-house experimental and analytical erosion studies and AFBC development efforts. (FY 1989 - $0.5M)	0.5
– Initiate proof-of-concept testing within the Advanced Concepts Program. (FY 1989 - $0.7M)	0.4
– Continue subsystem development testing within the Special Applications Program. (FY 1989 - $1.0M)	0.4
– Continue low rank coal studies at UNDEMRC. (FY 1989 - $0.5M)	0.1
– Initiate cooperative research with WRI. (FY 1989 - $0.0M)	0.3
Pressurized Fluidized Bed Combustion	
– Initiate advanced second generation PFBC systems component research efforts. (FY 1989 - $0.0M)	0.2
– Continue modeling studies and mechanisms for tube wastage alloys for long term testing. Provide technical and program management support. (FY 1989 - $0.9M)	0.6
– Continue research efforts at METC on PFB dynamics, systems analysis and combustion characterization, technology and economic analysis assess-	1.7

FY 1990 Budget (con'd)	Dollars in Millions
ment, evaluation of alternate advanced PFB systems and low rank coal listing at UNDEMRC. (FY 1989 - $1.9M)	
– Continue Advanced Concepts Phase II development and proceed with phase III, if appropriate. (FY 1989 - $4.5M)	4.1
– Continue Hot Gas Clean-up Test Stream design evaluations for installation at TIDD PFB Demonstration Plant. (FY 1989 - $2.0M)	0.0
• **Advanced Combustion Technology**	
– Continue development of the most promising advanced combustion systems for industrial, utility, commercial and residential applications. (FY 1989 - $5.2M)	1.8
– Continue in-house activities on combustion enhancement and pollution suppression research including data base development for technology transfer to the private sector. Continue to provide technical and program management support. (FY 1989 - $1.0M)	0.8
• **Alternative Fuels Utilization**	
– Complete formulation and characterization of coal-based fuels in support of the advanced combustion systems program. Continue transport, handling and storage studies, and combustion characterization of beneficiated coal based fuels. Continue project management support. Assess and test deeply beneficiated coals for retrofitting large pre-NSPS coal-fired boilers for acid rain control. Continue cooperative agreement with UNDEMRC. Provide technical and program management support. (FY 1989 - $5.5M)	3.7
Total, Combustion Systems	**$15.8**

Fuel Cells

Funding Activities	Dollars in millions FY 1988	FY1989	FY1990
Advanced Research	$ 1.5	$ 1.6	$ 1.0
Phosphoric Acid Systems	13.2	9.5	0.0
Molten Carbonate Systems	11.1	7.1	3.4
Advanced Concepts	8.4	8.3	2.1
TOTAL	$34.2	$26.5	$ 6.5

Background

- The objectives of the Fuel Cells program are to support high risk, high payoff technology base development and to assist private industry in developing hydrocarbon fuel conversion technologies to improve the cost effective, efficient and environmentally acceptable use of conventional and alternative hydrocarbon fuels.
- Advanced research, fundamental and generic in nature, is conducted to better understand the basis of the underlying processes involved in fuel cell operation and to explore novel concepts and advanced materials.
- Phosphoric acid systems have reached a near-commercial technical status with large scale testing underway. The Department proposes that any further technology development of phosphoric acid fuel cells be the responsibility of the private sector.
- The technical feasibility of molten carbonate fuel cells operating at approximately 60 percent electrical conversion efficiency (natural gas to busbar) has been forecast by single cell testing. The complexity and associated capital costs of advanced fuel cell systems are projected to be less than those for first generation phosphoric acid fuel cell systems.
- The solid oxide fuel cell is an advanced, high temperature solid state fuel cell that offers promise in electric utility and in cogeneration applications in industrial and commercial sectors.

FY 1990 Budget	Dollars in Millions
• **Advanced Research**	
– Continue generic research in basic electrochemistry science. (FY 1989 - $1.6M)	$ 1.0

FY 1990 Budget (con'd)

	Dollars in Millions
• **Molten Carbonate Systems**	3.2
– Complete the three ongoing coal-fueled molten carbonate fuel cell (MCFC) stack technologies leading to a new competitive action to select the most promising MCFC technology. (FY 1989 - $6.8M)	0.2
– Continue systems assessment of MCFC systems, and program management support. (FY 1989 - $0.3M)	
• **Advanced Concepts**	1.5
– Continue development of tubular solid oxide fuel cell (SOFC) technology for coal-fueled applications. (FY 1989 - $6.9M)	0.6
– Continue gasification/solid oxide fuel cell system analysis and materials characterization and development. Continue program management support. (FY 1989 - $1.4M)	
Total, Fuel Cells	$ 6.5

Heat Engines

Funding Activities	Dollars in millions FY 1988	FY1989	FY1990
Gas Turbines	$ 11.0	$ 13.1	$ 6.5
Diesel Engines	7.0	9.7	2.4
TOTAL	$ 18.0	$ 22.8	$ 8.9

Background

- The principal goal of this program is to establish a technical data base through selected research which will enable the private sector to develop the technology needed for direct firing of coal and to assess the commercial viability of coal-fueled power conversion systems.

- The program focuses on key technical problems associated with substituting coal or coal-derived gaseous fuels for distillate fuels or natural gas in gas turbine and diesel power conversion systems.
- Applications for this technology include industrial cogeneration, combined cycle electric power generation, repowering of existing generating capacity, and power sources for both rail and marine transportation.
- The FY 1990 budget request for Heat Engines is believed to be appropriate given current fiscal constraints. It is not necessary to fund multiple approaches in this program area, particularly in times of funding limitations. We believe that funding the most advantageous technical approaches will still provide for a strong development activity.

FY 1990 Budget	Dollars in Millions
• **Gas Turbines**	
– Continue coal-fueled gas turbine integrated systems testing with one contractor. (FY 1989 - $9.7M)	$ 3.8
– Continue pressurized coal combustion testing, advanced combustion test facility fabrication, and systems analyses. Continue low rank coal activities and program management support. (FY 1989 - $3.4M)	2.7
• **Diesel Engines**	
– Continue coal-fueled diesel engine integrated system development with one contractor. Continue combustion testing and systems analysis, low-rank coal activities, and program management support. (FY 1989 - $9.7M)	2.4
Total, Heat Engines	$ 8.9

Underground Coal Gasification

Funding Activities	FY 1988	FY1989	FY1990
	Dollars in Millions		
Gasification Tech. Develop.	$ 1.7	$ 0.3	$ 0.2
Environmental & Adv. Research	1.1	1.1	0.2
TOTAL	$ 2.8	$ 1.4	$ 0.4

Background

- This program supports the development of viable technology for in situ conversion of coal to a cleaner burning, easily transportable gaseous fuel.
- Program efforts are directed toward the definition of technical, operational, and environmental parameters sufficient to allow industry to make decisions concerning the commercial development of the technology.

FY 1990 Budget	Dollars in Millions
• **Gasification Technology Development**	
– Continue cooperative research efforts with WRI. (FY 1989 - $0.3M)	$ 0.2
• **Environmental and Advanced Research**	
– Continue environmental compliance, restoration, and reclamation activities at historical UCG test sites as required by law. (FY 1989 - $1.1M)	0.2
Total, Underground Coal Gasification	**$ 0.4**

Magnetohydrodynamics

	Dollars in millions		
Funding Activities	**FY 1988**	**FY1989**	**FY1990**
Proof-of-Concept Topping Cycle	**$ 21.1**	**$ 24.1**	**$ 0.0**
Proof-of-Concept Bottoming Cycle	**8.4**	**8.8**	**0.0**
Proof-of-Concept Seed Regeneration	**0.9**	**0.2**	**0.0**
System Studies, Supporting Research & Conceptual Design	**4.6**	**3.9**	**0.0**
TOTAL	**$ 35.0**	**$37.0**	**$ 0.0**

Background

- The current FY 1989 MHD program continues the second year of the planned five-year proof-of-concept (POC) program which is based on the Department's June 1984 Coal-Fired MHD Preliminary Transition and Program Plan (and outlined in the FY 1988 MHD Program Plan). This

program has been providing the design basis for the development of components and subsystems and furnishing the technology base for integrated, long duration, POC testing. Long duration POC testing would be needed for the advancement of the MHD technology to the retrofit demonstration stage which is a necessary prerequisite for subsequent commercial application.

FY 1990 Budget	Dollars in Millions
– No funds have been requested for FY 1990. Since it is estimated that $114 million (in constant FY 1988 dollars) is needed to complete POC testing, the Department believes that the cost of continuing its MHD program is not affordable in light of current fiscal constraints. (FY 1989 - $37.0M)	$ 0.0

Surface Coal Gasification

Funding Activities	FY 1988	FY1989	FY1990
	Dollars in millions		
Advanced Research	$ 2.7	$ 2.7	$ 0.7
Systems for Power Production	11.2	5.9	1.2
Systems for Industrial Fuel Gas Production	1.4	0.9	0.8
Systems for Synthesis Gas Production	1.9	2.5	1.1
Systems for Coproducts Production	5.3	9.1	4.9
Great Plains Coal Gasification Project	0.5	0.5	0.0
TOTAL	$23.0	$21.6	$ 8.7

Background

- The Surface Coal Gasification program is organized to foster the development of advanced gasifier systems for the production of: electric power, synthesis gas (for synthetic natural gas, indirect liquefaction, and chemical feedstocks), industrial fuel gas, and coproducts (simultaneous production of solids, liquids, and gases). This activity also provides for basic and fundamental research related to surface coal gasification processes including studies of reaction mechanisms and chemistry.

FY 1990 Budget	Dollars in Millions
• **Advanced Research**	
– Conduct work on product and precursor properties of condensible hydrocarbons and concepts for bulk gas separation. Continue coal gasification system assessment and modeling efforts, and conduct ash agglomeration studies in fluidized bed gasifiers. (FY 1989 - $2.1M)	$ 0.6
– Continue work on separating hydrogen from synthesized gas using ion exchange membranes. (FY 1989 - $0.5M)	0.1
• **Systems for Power Production**	
– Continue METC in-house sulfur kinetic studies and technical and program management support. (FY 1989 - $1.8M)	0.7
– Continue development and testing of hot desulfurization in an entrained flow reactor system for power generation. (FY 1989 - $1.4M)	0.5
• **Systems for Industrial Fuel Gas Production**	
– Continue operation of the fluidized bed reactor at METC as well as continuing support for the planning, implementation, and application of the gasification data base. Continue instrumentation research efforts. Provide technical and program management support. (FY 1989 - $0.9M)	0.8
• **System for Synthesis Gas Production**	
– Continue engineering and technical support for the joint DOE/GRI program. (FY 1989 - $0.5M)	0.2
– Continue development for hydrogen production from low rank coal. (FY 1989 - $0.8M)	0.5
– Continue systems analysis and model development efforts. Provide technical and program management support. (FY 1989 - $0.5M)	0.4

FY 1990 Budget (con'd)

	Dollars in Millions
• **Systems for Coproducts Production**	
– Conduct mild gasification studies to establish a matrix of product yields and investigate product options for coal-based fuels from mild gasification. (FY 1989 - $8.1M)	3.2
– Evaluate advanced technologies for treating and upgrading low rank coals. (FY 1989 - $0.4M)	1.0
– Investigate pyrolysis of coal under mild gasification conditions and upgrading condensibles to marketable high value fuels. (FY 1989 - $0.0M)	0.4
– Continue modeling analysis and system analysis. Provide technical and program management support. (FY 1989 - $0.5M)	0.3
Total, Surface Coal Gasification	$ 8.7

PETROLEUM AND GAS

Advanced Extraction and Process Technology

Funding Activities	Dollars in millions FY 1988	FY1989	FY1990
Arctic and Offshore Research	$ 0.4	$ 0.4	$ 0.0
Fundamental Geoscience and Extraction Research	2.0	2.7	1.6
Supporting Technology and Environmental Research	1.0	0.9	3.0
University Geoscience Research	0.0	0.2	0.0
TOTAL	$ 3.4	$ 4.2	$4.6

Background

- The Advanced Extraction and Process Technology (AEPT) program pursues new concepts to achieve major increases in efficiency and cost reduction of recovery techniques for oil, gas, and oil shale.

- The goals of this research program are: (1) to conduct fundamental research relevant to recovery of oil, gas and oil shale, (2) to pursue application of discoveries from unexplored new concepts which may achieve major increases in the recovery of oil, gas and oil shale resources, and (3) to develop a fossil energy-related knowledge base that will improve the economics of fossil fuel production in the Alaskan Arctic and U.S. offshore operations and will expand the reserves.

FY 1990 Budget	Dollars in Millions
• **Fundamental Geoscience and Extraction Research**	
– Continue research on geoscience and extraction technology and development of advanced instrumentation to measure reservoir characteristics and thermal fronts. (FY 1989 - $2.7M)	$ 1.6
• **Supporting Technology and Environmental Research**	
– Continue a program of fundamental studies including crosscutting research in petroleum chemistry focusing on structural characterization and determination of the structure-property relationship of heavy crude, intermediate product stream, product, and byproduct. (FY 1989 - $0.7M)	0.6
– Provide funding for joint government-industry cooperative research activities at Western Research Institute and the University of North Dakota Energy and Minerals Research Center (FY 1989 - $0.0M)	2.3
– Fund technical and program management support. (FY 1989 - $0.1M)	0.1
Total, Advanced Extraction and Process Technology	$ 4.6

Enhanced Oil Recovery

Funding Activities	Dollars in Millions FY 1988	FY1989	FY1990
Heavy Oil	$ 3.7	$ 4.3	$ 4.1
Light Oil	9.9	16.7	14.1
Tar Sands	2.0	2.6	0.0
Pilot Ventures Program	1.0	0.0	0.0
TOTAL	$16.6	$23.6	$18.2

Background

- Enhanced oil recovery (EOR) represents technologies that can increase domestic oil production between now and the critical time when the nation will likely rely more extensively on synthetic fuels.
- There is a need for the Department of Energy to assist industry in obtaining a better understanding of the mechanisms and behavior of advanced and novel EOR processes that can lead to improved and new process concepts for the recovery of presently unrecoverable oil resources.
- Program concentration is also upon the development of advanced oil recovery techniques and on reservoir characterization as part of the Fossil Energy Geoscience effort.

FY 1990 Activities	Dollars in Millions
• **Heavy Oil**	
– Continue basic research in mobility control mechanisms of steamflood additives. Define the mechanisms by which foam increases oil recovery and develop analytical and numerical models. Develop relative permeability and capillary pressure data. (FY 1989 - $1.3M)	$ 1.6
– Continue cooperative research with Venezuela on petroleum reservoir characterization and recovery studies and conduct technical and analytical assessments related to geoscience and recovery technology. (FY 1989 - $0.5M)	0.5
– Continue a geoscience characterization program, research in novel extraction approaches to presently deemed unrecoverable, heavy oil resources, and fundamental studies of reservoir characteristics and injection fluid interactions. Provide program support. (FY 1989 - $2.5M)	2.0
• **Light Oil**	
– Continue a broad based program of research in light oil recovery techniques and conduct related planning, technical and analytical assessments. (FY 1989 - $4.2M)	4.2
– Continue a geoscience effort and reservoir characterization and related fundamental studies addressing	5.1

FY 1990 Budget (con'd)	Dollars in Millions
definition of reservoir structure and composition. (FY 1989 - $6.1M)	
– Continue microbiological studies and explore the feasibility of other novel methods of extraction of residual oil resources. (FY 1989 - $1.6M)	1.2
– Continue a research program to utilize CO_2 and other gas recovery methods in a variety of situations to promote the efficient, effective and predictable application of these techniques. (FY 1989 - $1.8M)	1.8
– Continue industry/state cooperative work to apply lab scale EOR concepts in mature fields. Develop retrofit technology to reduce stripper well costs. Provide program support. (FY 1989 - $3.0M)	1.8
Total, Enhanced Oil Recovery	**$18.2**

Oil Shale

Funding Activities	Dollars in Millions FY 1988	FY1989	FY1990
Oil Shale Technology Base	$ 6.7	$ 7.5	$ 1.0
Environmental Mitigation	2.8	3.0	0.7
TOTAL	$ 9.5	$ 10.5	$ 1.7

Background

- Oil shale technology development involves the development of extraction and conversion processes designed to convert oil shale to various liquid fuels. The program focuses on basic research to systematically study the chemistry, kinetics, and emissions related to eastern and western shale processing.
- The Environmental Mitigation program attempts to improve the technological base that can reduce the economic and environmental constraints to industrial development of U.S. oil shale resources and can increase the amount of resources that may be used economically.

FY 1990 Budget	Dollars in Millions
• Oil Shale Technology Base	
– Continue METC in-house research on kinetics with modeling support, development of system analysis capability, and applied studies. Fund WRI to perform characterization of reference shales. (FY 1989 - $7.5M)	$ 1.0
• Environmental Mitigation	
– Continue studies of mechanisms of pollutant generation and fate, process stream characterization, and development of an environmental data base. (FY 1989 - $3.0M)	0.7
Total, Oil Shale	$ 1.7

Unconventional Gas Recovery

	Dollars in Millions		
Funding Activities	FY 1988	FY1989	FY1990
Eastern Gas Shales	$ 2.3	$ 3.1	$ 0.3
Western Tight Gas Sands	3.3	3.3	0.3
Environmental and Advanced Research	4.9	5.0	3.5
TOTAL	$10.5	$11.4	$ 4.1

Background

- This program fosters the development of advanced technologies for the extraction of natural gas from currently unrecoverable gas resources by reducing the uncertainty surrounding the potential magnitude of the unconventional gas resources and the conditions under which they can be produced. The program will develop and improve extraction technologies only to the point where concepts are proven and economics established.

FY 1990 Budget	Dollars in Millions
• Eastern Gas Shales	
– Continue limited in-house support for and update the predictive models associated with reservoir and	$ 0.3

FY 1990 Budget (con'd)	Dollars in Millions
stimulation performance; continue minimal systems studies in support of production strategies. (FY 1989 - $3.1M)	
• **Western Tight Gas Sands**	
– Continue limited in-house work with predictive reservoir and stimulation models; expand technical data base. Continue minimal systems analyses in support of production strategies and forecasts of regional production patterns in light of multi-well results. (FY 1989 - $3.3M)	0.3
• **Environmental and Advanced Research**	
– Continue in-house geologic, geophysical and geochemical efforts to study deep source gas generation potential for sediments subducted by plate tectonic convergence. (FY 1989 - $0.1M)	0.2
– Limit studies to determine problems with heavy oil reservoirs containing hydrates. Continue in-house research on gas hydrates and catalyst systems for converting natural gas to liquids. (FY 1989 - $2.4M)	0.9
– Continue secondary gas recovery program. (FY 1989 - $2.5M)	2.4
Total, Unconventional Gas Recovery	**$ 4.1**

MANAGEMENT AND OTHER BUDGET ITEMS

Program Direction and Management Support

Dollars in millions

Funding Activities	FY 1988	FY1989	FY1990
Headquarters Program Direction			
Salaries and Benefits	$ 9.1	$ 9.5	$ 8.5
Travel	0.5	0.5	0.4
Contract Services	3.1	6.2	0.2
ETC Program Direction			
Salaries and Benefits	$19.0	$18.6	$13.6
Travel	1.0	0.9	0.6
Contract Services	26.3	31.3	2.2
Federal Inspector for the Alaskan Natural Gas Transportation System	$ 0.2	$ 0.3	$ 0.3
TOTAL	$59.2	$67.3	$25.8

Background

This activity provides funding for salaries, benefits and overhead expenses for the management of FE programs at Headquarters and the Energy Technology Centers:

- The Headquarters staff is responsible for overall program direction which implements DOE policy and communicates that policy to the Energy Technology Centers, sets program objectives, develops program plans and evaluates alternative program strategies, develops and defends budget requests to the Office of Management and Budget and to the Congress, approves procurement plans, monitors work progress, evaluates projects, approves revisions in work plans as required to attain program goals, and supports the Office of Geoscience Research.

- The Energy Technology Centers support day-to-day project management functions for assigned programmatic areas including contract and National Laboratory monitoring, development and maintenance of project budget and procurement plans, and other activities related to program and site support.

- The Office of the Federal Inspector for the Alaska Natural Gas Transportation System is responsible for coordinating all Federal activities pertaining to the construction and initial operation of the pipeline. The Office of the Federal Inspector also enforces federal laws and permits, and monitors activities that affect the system.

FY 1990 Budget	Dollars in Millions
• **Headquarters Program Direction**	
– Provide funds for salaries and benefits of 125 FTEs at Headquarters. This staff implements and communicates policy to the ETC's, sets program objectives, develops program plans and evaluates alternative strategies; develops and defends budget requests; approves procurement plans, and monitors work programs. (FY 1989 - $9.5M)	$ 8.5
– Provide funds for support of the activities stated above. Both domestic and international travel is conducted. (FY 1989 - $0.5M)	0.4
– Provide for contractual services that are generic to the entire FE program. Included are items such as printing, computer services, technical support services, conferences, etc. (FY 1989 - $6.3M)	0.2
• **ETC Program Direction**	
– Provide funds for salaries and benefits of the ETC staff of 243 FTEs. Activities of the staff include contract and lab monitoring; development and maintenance of project, budget and procurement plans, and other activities related to program and site support. (FY 1989 - $18.6M)	13.6
– Provide funds for travel in support of the coordination of the above activities in the attainment of program goals, both domestically and abroad. (FY 1989 - $0.9M)	0.6
– Provide funds for facility operations, maintenance, finance and administrative support and other costs not appropriately chargeable to R&D projects, in support of this level of FTE's. (FY 1989 - $31.3M)	2.2
• **Federal Inspector for the Alaskan Natural Gas Transportation System**	
– Provide funds for administrative and support functions; continue to assess developments in U.S. and Canadian energy markets and maintain liaison with project sponsors, producers, other government agen-	0.3

FY 1990 Budget	Dollars in Millions
cies, State of Alaska and the Canadian government. (FY 1989 - $0.3M)	
Total, Program Direction and Management Support	**$25.8**

Plant and Capital Equipment

Funding Activities	Dollars in millions FY 1988	FY1989	FY1990
Capital Equipment	$ 0.5	$ 0.5	$ 0.0
Construction	17.7	21.2	1.9
TOTAL	$18.2	$21.7	$ 1.9

Background

- Capital equipment is purchased annually to replace obsolete equipment so that the analytical capabilities are constantly being upgraded at the Energy Technology Centers (ETCs) and the National Laboratories .
- General plant projects are essential to the safe, efficient operation of the ETCs and construction is dedicated to a number of improvements, alterations and additions at each of the Energy Technology Centers.
- The major reduction between the FY 1989 appropriations and the FY 1990 request is primarily the result of the completion of the government's funding commitments for two Congressionally-added construction projects (at West Virginia University and the University of Oklahoma).

FY 1990 Budget	Dollars in Millions
• Construction	
– Continue construction of chemical engineering laboratories project at PETC. (FY 1989 - $1.3M)	$ 1.9
Total, Plant and Capital Equipment	**$ 1.9**

Environmental Restoration

Funding Activities	Dollars in millions FY 1988	FY1989	FY1990
RCRA Remedial Actions	$ 0.0	$ 0.0	$ 0.0
CERCLA Remedial Actions	0.0	0.0	1.0
TOTAL	$ 0.0	$ 0.0	$ 1.0

Background

- In May 1983, the Pittsburgh and Midway Coal Mining Co. (P&M), the DOE contractor/operator of the Ft. Lewis Pilot Plant (Tacoma, Washington), was notified by EPA that, under the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA), it was potentially liable along with hundreds of others, for cleanup of the Western Processing Site. The site was used for disposal of industrial waste from the Solvent Refined Coal pilot plant operated from 1974 to 1981.
- DOE, P&M and others have agreed to pay the costs of cleaning up the site and a trust fund has been established to receive and disburse payments.
- Total site cleanup (Phase I/Surface and Phase II/Subsurface) was estimated to be a minimum of $40 million. Currently, cleanup is in Phase II and monitoring will not be complete until the year 2020.
- In May 1988, the Laramie Project Office received a Notice of Violation from the Wyoming Department of Environmental Quality. As a result of this Notice, the Department has agreed to assist in the cleanup of the Rock Springs site.

FY 1990 Budget	Dollars in Millions
- Fund DOE share of Ft. Lewis trust fund Phase II-cleanup of Western Superfund site. (FY 1989 - $0.0M)	$ 1.0
- Continue cleanup of the Rock Springs site including groundwater sampling and analyses, pumping and water treatment, well abandonment and reseeding using prior year funds. (FY 1989 - $0.0M)	0.0
Total, Environmental Restoration	**$ 1.0**

Senator FORD. Thank you, Mr. Secretary.

We have had two Senators join us. Senator Conrad, we welcome you to the hearing. Do you have a statement or any comments you would like to make before we start the questioning?

Senator CONRAD. I have a statement that I would just like to enter into the record, Mr. Chairman.

Senator FORD. It will be included in the record.

[The prepared statement of Senator Conrad follows:]

STATEMENT OF SENATOR KENT CONRAD

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
HEARING ON FOSSIL FUEL BUDGET

JULY 11, 1989

I wish to thank the distinguished Chairman for holding this hearing on the Department of Energy's fossil fuel research and development budget for FY 1990. One of the most critical components of this program is the Clean Coal Technology Program (CCTP).

Coal is the United States' most abundant fossil fuel resource. We have made tremendous strides in the past few years in developing new ways of using coal more efficiently and cleanly. The Clean Coal Technology Program has helped make this possible. I am gratified that the President's budget returns the CCTP to its original timetable and funding levels. In this time of increasing oil imports our energy security is all the more fragile. We need to insure that coal is there to meet our energy needs in the future.

We are also in a time of increasing sensitivity toward the environment and the effects that energy production and use have on the ecosystem. The CCTP provides a way to bring new levels of efficiency and, at the same time, lower emissions from the combustion of coal. We must keep this vital research going.

I also support the inclusion in the budget of initiatives that will facilitate increased use and export of Western coal. This coal makes up over half of the proven coal reserves in the U.S. today and it is low in sulfur content. It offers the promise of meeting increasing needs for power in the United States and abroad, particularly the Pacific Rim area.

I am concerned, however, about the proposed budget for fossil fuel research and development. It reduces funding for fossil energy research programs by more than half. Dr. Squires statement, given on behalf of the American Chemical Society, points out that we do not have enough basic knowledge about the combustion characteristics of coal to predict what will happen when coal is subjected to new types of combustion. He points out that we must spend at least $10 million on testing and operation in order to be confident in the behavior of each new system. We must continue to fund basic fossil fuel research at previous levels in order to make sure that the level of research and the number of researchers in this field is sufficient to ensure that new developments in energy efficiency will continue. We cannot afford to cut back in this area at this critical time.

Thank you Mr. Chairman for the opportunity to present this statement to the subcommittee.

Senator FORD. Senator Burns, do you have a statement you would like to make before we get started here?

STATEMENT OF HON. CONRAD BURNS, U.S. SENATOR FROM MONTANA

Senator BURNS. Thank you, Mr. Chairman, and thank you for the opportunity of offering a statement. We are in the process across the way, as you well know, so I appreciate it. And I appreciate the opportunity just to say a few words in favor of clean coal technologies.

It is becoming quite clear that the United States has to take aggressive actions to begin to reduce the effects of acid rain in the northeast United States and in Canada. And maybe more important, we need to significantly reduce our contribution of carbon dioxide to the atmosphere. The improvement in coal burning power plant emissions will go a long way toward the improvement of air quality.

However, I am disturbed to discover that the administration has again not elected to fund the MHD project in fiscal year 1990. This technology is capable, during burning of fossil fuels, of reducing sulfur oxides by 95 percent, of operating at 30 percent below the current nitrous oxide standards, and of reducing the carbon dioxide by 33 percent.

MHD provides an economical method of retrofitting conventional power plants to improve electrical output while obtaining efficiency gains of over 50 percent. All this is accomplished without the expensive scrubbers, and it will produce very little sludge.

MHD is in the middle of the proof of concept development plan targeted for completion in fiscal year 1992. We are now in the third year of a five year program. It would be unfortunate, maybe foolhardy even, to not complete the development of such a promising technology.

The Butte facility is completing the design of an MHD unit to be retrofitted to the Montana powerplant. This project will be coshared with industry according to the legislative formula. This retrofitted plant will be the first operating generation plant using this new technology. And this will be the final development step before commercialization of MHD.

So, I would ask that this committee restore the MHD program authorization of $47 million in fiscal year 1990. Completion of this program will have spinoffs that will many times pay off this investment.

And I thank you, Mr. Chairman, for that courtesy.

Senator FORD. Thank you, Senator Burns.

We are pleased to have the ranking member of the subcommittee and the ranking member of the full Energy Committee, Senator Domenici, to join the subcommittee. Senator, do you have a statement you would like to make?

Senator DOMENICI. I think not, Mr. Chairman. I think this is a very relevant hearing and we have some good witnesses. I thank you for the opportunity to make some remarks. I will save them for my questions.

Senator FORD. We have also been joined by my colleague from Kentucky, Senator McConnell. Do you have any statement?

Senator MCCONNELL. Thank you, Mr. Chairman. No, I will skip an opening statement.

Senator FORD. We are going to try then to hold our questioning to about 10 minutes each, and if we need to go around, why, we will hold it until the second round. So, we will try to watch the clock, and if you will watch the clock, we will try to hold our questions to 10 minutes. And I am sure the administration would be delighted to answer questions in writing if they are submitted to them.

Mr. Secretary, it is my understanding that the acid rain portion of the President's clean air legislation will include extensions for and promote the use of six specific technologies. They are MHD; atmospheric and pressurized fluidized bed combustors, known as AFBC and PFBC; integrated gasification combined cycles, IGCC; direct and indirect coal-fired turbines; and fuel cells integrated with gasification combined cycle units. Am I correct in that assumption?

Mr. WAMPLER. Let me say this, Mr. Chairman. The Administration's acid rain bill or Clean Air Act legislation at this point in time is certainly still a moving target, since the President has not yet submitted it.

Senator FORD. A moving target is hard to hit, and a skinny one is even harder, you know.

Mr. WAMPLER. I realize that, Mr. Chairman, but those were the items that were included in the draft as it last stood.

Senator FORD. Well, when this moving target last moved my way, this is what I saw in it.

Mr. Secretary, does the Department agree with the administration's term of "repowering"?

Mr. WAMPLER. Certainly the Department does agree with that. I think that that is a good description of the repowering technology.

Senator FORD. Well then, Mr. Secretary, why does the administration propose zero funding for MHD and phosphoric fuel cells research and cuts in program areas focusing on IGCC and the two atmospheric and pressurized fluidized bed combustors? The combustion systems are cut $11 million. Molten carbonate fuel cells were cut by $3.7 million. If you agree with the repowering, why did we have all the cuts?

Mr. WAMPLER. Mr. Chairman, I have to take those in turn. The MHD program cuts were cuts that we suggested due to the affordability issue.

The phosphoric acid fuel cell cuts were due to the fact that we considered phosphoric acid fuel cells to be at a commercial-readiness state. The private sector can penetrate the industry with those.

The other cuts that you are referring to are basically cuts of an overall nature that represent the gap or the delta between the Administration's request and the amount of appropriations for last year. There may be some adjustment on that.

Also, AFBC and PFBC combustion systems are both projects in the Clean Coal Program already negotiated. So, some of the cost burden can be borne with that. These technologies we felt we

should define to make them eligible for the repowering definition under the President's bill

Senator FORD. Well, the 29 projects selected—I believe there are 29—in round 1 and round 2 of the clean coal program are a mixture of retrofit and repowering technologies. Can you provide the committee with an idea of how many projects fit into each category?

Mr. WAMPLER. Seven of the projects under both Rounds were repowering projects and 22 were retrofit projects.

Senator FORD. The President has indicated that he would offer an extension for compliance with acid rain deadlines for certain repowering technologies only. Given this statement, will the next Rounds, 3, 4, and 5, focus on repowering only?

Mr. WAMPLER. It is undecided at this point in time. I think the best way to answer that is to point out a pro and a con. If you look at the retrofit technologies, they will generally be ready prior to the year 2000. They are much further advanced. They are lower-cost projects primarily.

The repowering projects, as you go forward with them, take much longer to design, build, install and test. So, while it is undecided at this point in time, I think it is important to realize that certain of the retrofit projects we have under way and probably will fund in the future, if we decide to go that way, will also be important to enable utilities to comply with the law, because no single configuration or design that we have ever come up with in the program is sufficient for all the power plants in the country.

Senator FORD. Mr. Secretary, why sponsor 22 retrofit technologies and not provide incentives for its use? Decisions on the technology mode will be made well before the year 2000.

Mr. WAMPLER. We think at this time that the retrofit technologies in those instances that they are appropriate for a particular power plant are quite likely to deploy on their own without any extra incentives.

Senator FORD. We will get to the power companies and see what they think about that in a minute.

GAO in March 1989 reported examining the status of the clean coal program, and stated that DOE experienced difficulties in completing contracts with project sponsors. What have been some of the difficulties, Mr. Secretary?

Mr. WAMPLER. Some of the difficulties have been with private financing. The Round 1 projects, I think it is important to recognize, were a product of congressional action that had resulted in some very, very tight time constraints in the law itself, and it forced the Department of Energy to very quickly get a solicitation on the street and the private sector participants to very quickly respond. We found that a lot of the participants responded without fully checking out their private financing.

We had a problem with pre-award costs in the structure of Round 1. The Department could not pay pre-award costs.

We had problems with issues like patent and data rights.

The projects we found were not really well-defined.

There was a lack, in some cases, a clear lack, of corporate commitment to these projects because they were made up of a group of sponsors rather than one or two.

And also the issue that has been with us since the beginning of this program seemed to be an issue, and that was the issue of repayment.

Senator FORD. I have time for about one more question, and I have some questions for you in writing, Mr. Secretary, that I will submit to you.

The House report on the Interior appropriations bill expresses some concern that DOE may be hiding overhead funds throughout the research budget. They believe that overhead should be identified in the "program direction" category. The report states that this has the effect of overstating the amount of research that could be accomplished for funds in the budget. Mr. Secretary, this troubles me considerably. Is the House correct? And what percentage of funds in the budget is actually for research and development?

Mr. WAMPLER. I had difficulty understanding the rationale behind the House report. There are certainly no funds hidden.

The way the budget was put together was to try to put as many dollars as we could into research and development within that $160 million or so that we requested for funds, and it was a little bit different approach than we had used in the past. So, what we tried to cut out in that budget was a lot of support services and contractor costs that we had included in the past.

And if you look at the budget and break it down—we did a rough breakdown on it—about 85 percent of those dollars are for research and development, and that includes both in-house research and personnel costs and contracted-out research. So, it is a product of planning a little different way of doing the job, as I understand it, but certainly not any attempt to hide any kind of funds. Certainly I simply do not know how to do that.

Senator FORD. My time is up and we have gone by the distinguished Senator from Alabama, Senator Heflin. Senator Heflin, do you have a statement you would like to make before we move on?

Senator HEFLIN. I will forego making a statement to cut down on time.

Senator FORD. All right. We will do that.

Senator Wirth.

Senator WIRTH. Thank you very much, Mr. Chairman.

Mr. Wampler, can you expand a little bit beyond the statement that you made about western coal? You talk about there that this is a priority and that maybe what you are going to be doing is looking at coal as a potential fuel for railroads and maybe export markets. Do you really have an overall strategy for how you are going to balance off the research on western coal versus eastern coal?

Mr. WAMPLER. We do have a strategy. And let me say at the outset, Senator, that I totally agree with you that the Department's budget in the past several years has certainly not been balanced when you look at western coal versus eastern coal. There are several reasons for this. A lot of the research that we do in the East is applicable to western coal. Some is not, of course.

So, we started about a year ago, perhaps a little bit longer than that, to look at the research and development side of the Department of Energy's budget to see if we could develop a program that had the proper amount of research and development going that we could feed into programs like the Clean Coal Technology Program.

Part of the problem with clean coal technology is the amount of research and development we have done on western coals has been fairly small as compared to eastern coals. So, we didn't have the infrastructure in the west to feed into demonstration projects.

Senator WIRTH. Maybe just to cut this short—maybe some of my colleagues are going to have questions to. I have a variety of things. Maybe I could as you to do this. Could you give me or send up to us the framework, first of all, what you want to do in the area of western coal, why it hasn't been done in the past, and what we are going to see in terms of budget commitments in that area?

Mr. WAMPLER. We certainly can do that.

[The information follows:]

WESTERN R&D

Fossil Energy is sponsoring R&D activities related to Western Resources under the following programs:

- o Coal Preparation

  (a) Western Research Institute (FY 1989 - $341; FY 1990 - $632)
  Research is being conducted on upgrading Western low-rank coals through drying and the effect this has on transportation costs. The drying technology being investigated is an inclined fluidized bed using CO_2 to inhibit oxidation developed at WRI.

  (b) University of North Dakota Energy and Minerals Research Center (UNDEMRC) (FY 1989 - $564; FY 1990 - $352)
  Research is being conducted on drying low-rank coals using a hot water drying technique developed at UNDEMRC. This project will be completed in FY 1989. In FY 1989, research activities will be initiated to investigate microbial desulfurization of Western coals.

- o Flue Gas Cleanup

  (a) UNDEMRC (FY 1989 - $422; FY 1990 - $0)
  Two research activities are being conducted. One is R&D on catalyst-coated filters for the combined removal of NO and particulates from coal-fired boiler flue gas. Bench scale testing is scheduled to be completed by the end of FY 1989.

  The other area involves the evaluation of flue gas conditioning agents that result in particulate capture in baghouses. This project is scheduled to be completed in FY 1990.

- o Waste Management

  (a) UNDEMRC (FY 1989 - $125; FY 1990 - $0)
  Studies cover the chemical characterization of low-rank coal wastes and the development of low permeability coal-waste liners for landfill cells.

  (b) State of Wyoming (FY 1989 - $0; FY 1990 - $1896)
  A Memorandum of Understanding with the State provides for 50% DOE cost sharing to initiate studies of the wastes produced in the processing of Western coals. Included are chemical characterization and wastewater treatment studies.

- Alternative Fuels

  (a) UNDEMRC (FY 1989 - $232; FY 1990 - $120)
  The research activity involves the testing of both low-rank coal water slurries and dry ultrafine coal in combustion test rigs built at UNDEMRC. In addition, slurry rheology and additives will be investigated.

- Pressurized Fluidized Bed

  (a) UNDEMRC (FY 1989 - $300; FY 1990 - $150)
  The research effort involves the evaluation of low-rank coal effects on corrosion and erosion of heat exchange surfaces through long-term testing and extensive metallorgraphic analysis of exposed tubes.

- Atmospheric Fluidized Bed

  (a) Western Research Institute (FY 1989 - $0; FY 1990 - $300)
  This research effort to be initiated in FY 1990 will investigate the application of atmospheric fluidized bed (AFB) technology to western low-rank coals (LRC). Combustion tests of LRC will be conducted in a circulating fluidized bed combustion (FBC) or other concept.

  (b) UNDEMRC (FY 1989 - $504; FY 1990 - $100)
  Research efforts focus on the suitability of LRC and LRC slurries for use in AFB advanced concepts and special applications for the light industrial, commercial and residential markets.

- Gas Stream Cleanup

  UNDEMRC (FY 1989 - $250; FY 1990 - $0)
  This research effort is expected to lead to development of a scientific and technical data base for fundamental low-rank coal reactions supporting advanced coal conversion systems.

- Coal Liquefaction

  (a) UNDEMRC (FY 1989 - $400; FY 1990 - $0)
  This work includes laboratory and bench scale studies on the use of low-rank (Western) coals in direct liquefaction processes.

  (b) Direct Liquefaction Program (FY 1989 - $17,333; FY 1990 - $2913)
  The Direct Liquefaction Program includes proof-of-concept (Wilsonville), bench scale, and laboratory scale research and development on improved processes. We estimate that 35 - 40 percent of this work utilizes Western coal resources.

- Heat Engines

  (a) UNDEMRC (FY 1989 - $334; FY 1990 - $290)
  Research is being conducted to burn Western low-rank coals in gas turbines and diesel engines.

- Surface Coal Gasification - Systems for Coproducts Production

  (a) Western Research Institute (FY 1989-$1,828; FY 1990-$1,117)
  Research is being conducted to develop an advanced mild gasification process using an inclined fluidized bed gasifier concept to produce liquids, gases, and char which will be used in the production of carbon black and electrodes. Research is also being conducted to characterize mild gasification liquids for upgrading to marketable fuels.

  (b) UNDEMRC - (FY 1989-$1,219; FY 1990-$1,138)
  Research is being conducted to develop an advanced mild process using a spouted fluidized bed gasifier to produce liquids, gases, and char for the production of form coke, metallurgical coke pellets, activated carbon and electrode and form coke binders. Research is also being conducted for converting low-rank coals to low-cost hydrogen and advanced waste-water treatment techniques.

  (c) TBD - (FY 1989-$0; FY 1990-$950)
  Characterization and evaluation of advanced technologies for treating and upgrading low-rank coals in order to increase their marketability.

Senator WIRTH. If you could do that, it seems to me maybe we can start from that as kind of a written statement or a written document. We both agree that what has been done in the past, again despite a great deal of support for the clean coal program from people from the west, is that the issues that relate to western coal simply have not been addressed by the Department. We agree with that and I think what we would like to see is a little more sense of urgency on your part of looking at these sets of issues. We have talked about that before. Thank you very much.

Let me jump, if I might, a moment to global warming. First of all, I will tell you I was a little bit disappointed with the rhetoric on page 10 of your analysis about the issue of global warming. It reads in paragraph 2 and then in paragraph 3 as if you don't really think that global warming as a phenomenon exists, and I think that really runs against the grain of what a preponderance, an overwhelming preponderance, of scientific evidence suggests. When you say "if the scientific ultimately shows," well, I think the scientific evidence is awful clear in that direction. I think you know that, and we know that. Sometimes perhaps your testimony gets changed or altered or impressed by OMB.

But anyway, I would hope that there is a greater sense of urgency in what you are doing than in the rhetoric here. And I know in talking to most of the people in the Department, they believe that there is a greater sense of clarity in the information about what is going on in global warming than what is reflected here. We both understand that. You don't have to comment on that, Mr. Wampler. I just wanted to note that for the record that it is a pretty limp statement on an issue that I think most people believe is overtaking us very rapidly.

Let me ask you very specifically. You don't have to comment on that background. There is nothing you can do about the politics of that at the moment.

Is there a focal point in the Department for focusing on issues of global warming? Is there someplace in the Department where their responsibility is looking at what you are doing, looking at other activities in the Department?

Mr. WAMPLER. The focus is or will be in our Policy office. That will be the focal point for all these issues. And I think that is a very good place to put it because we have all the different technological bases feeding into that.

If I could take the liberty to respond a little bit to your comment.

Senator WIRTH. Please.

Mr. WAMPLER. We have seen quite a bit of evidence, pro and con, on global warming. And I think that what our statement says—and it didn't mean to be wishy-washy, but what it simply says is that, while the debate is going on, let's not wait. Let's start with technologies that would mitigate CO_2 buildup.

Senator WIRTH. I agree with that. The evidence pro and con is there are a few people, it seems to me, sort of on the fringe of most of this debate or on the con side. The overwhelming evidence is elsewhere. And I think that the overwhelming evidence in the scientific community is now not whether it is getting warmer, but how fast and how much. And we have to deal I think with that reality much more than sitting back and having a very small minori-

ty of individuals couching the debate as if it is a balance because it is simply not there anymore.

In any case, leaving that aside, going back to a focus in the Department, as you say, even if there is a debate, we shouldn't allow that debate to preclude actions that ought to be taken which would suggest that there ought to be some mechanism I think within the Department of Energy. Senator Johnston and I have proposed that there be a development of an office of climate protection in the Department of Energy that would be really a repository of looking at what the Department was doing and try and understand steps taken in the Department, initiatives that have been requested from outside, what the evidence suggests and how that frames in the Department.

Does that seem like a good idea to you to create that kind of a mechanism?

Mr. WAMPLER. That is certainly a question more appropriately answered by the Secretary, but I think that having a mechanism within the Department that addresses, in the fashion that you propose, those kinds of issues is very appropriate, yes.

Senator WIRTH. Do you have any kind of a mechanism now for looking at projects funded by the Department to see what impact those might have on the production of carbon dioxide resulting on global warming?

Mr. WAMPLER. Oh, we certainly do, and we are becoming, as we go forward in the rounds of clean coal technology, solicitations much more aware of that. We look at it internally in the Fossil Energy group. We do analyses. We know that all the technologies will do in terms of contributing to or reducing carbon dioxide.

Senator WIRTH. Do you do that analysis of all the projects now funded by the Department.

Mr. WAMPLER. We do that analysis. Yes, we do. We will be glad to furnish you with a list of that for all the technologies.

[The information follows:]

GLOBAL CLIMATE CHANGE

A table showing anticipated CO_2 emission changes from various technologies follows:

TABLE

CARBON DIOXIDE EMISSIONS FROM FOSSIL FUELED FACILITIES

Technology	Fuel	Efficiency (approx.)	Total CO2 (Million tons/year)	%Change
Conventional Pulverized Coal (w/o FGD)	Coal	35%	2.75	---
Conventional Pulverized Coal (w/FGD)	Coal	34%	2.83	+3%
Atmospheric Fluidized Bed Combustion	Coal	36%	Essentially no change	0
Pressurized Fluidized Bed Combustion	Coal	40%	2.48	-10%
Integrated Gasification Combined Cycle (IGCC)	Coal	42%	2.36	-14%
IGCC w/Fuel Cell	Coal	50%	1.98	-28%
Conventional Combustion w/Advanced Flue Gas Cleaning	Coal	35%	Essentially no change	0
Advanced Cleaning	Coal	36%	Essentially no change	0
MHD	Coal	55%	1.80	-34%
MHD	Natural Gas	50%	1.19	-57%
Turbine Combined Cycle	Natural Gas	47%	1.27	-54%
Fuel Cell	Natural Gas	55%	1.09	-60%

Assumptions: 2.8% sulfur coal, 11,600 BTU/lb
65% Capacity Factor
Nominal 500 MWe Electric Power Plant
90% sulfur removal (where required)

Senator WIRTH. I would like to see that to see what kind of analysis you do do and what the results of that are.

Finally, if I might, Mr. Wampler, we had some months ago introduced the Omnibus Energy Policy Act, with which you are familiar, the so-called global warming bill, and had sent it down to the Department. It is fundamentally an energy bill. This doesn't necessarily fall in your bailiwick, but I raise this now. Maybe you could nudge somebody down there or have whoever is with you to see if we might get a response back from the Department on that. There is a lot of interest on the Hill for moving with various aspects of the legislation. As I have said to the Secretary and to the Deputy Secretary and to others now coming in, we really would like to work with you on this. I think that there is an increasing understanding that we want to jointly get going on this.

Mr. WAMPLER. We will certainly relay that request back.

I think it is very refreshing to watch the methodology with which Secretary Watkins is beginning to develop an energy strategy, and I think you are going to see in this country for the first time in a very long time a comprehensive energy strategy developed that will have the input of the realm of parties out there. And I think that a lot is going to happen during the next year to two years in that area.

Senator WIRTH. I agree with that, and we are all very hopeful and I think very supportive of the Secretary in his initiatives and hope that he doesn't get swamped by nuclear issues while the energy issues are out there too. The poor guy has the worst job in town.

Thank you very much. Thank you, Mr. Chairman.

Senator FORD. Senator Rockefeller.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Mr. Secretary, you say in your prepared testimony that U.S. oil imports are rising beyond 40 percent, and I think that most people would agree that by the mid-1990s, they will be at least over 50 percent and perhaps substantially more than that.

I quote from your testimony: "The most pressing national energy need is to ensure that we maintain an adequate and secure supply of liquid fuels." But you propose to cut funding for liquid fuels research by 50 percent. And I am sort of interested in your rational for that.

Mr. WAMPLER. Well, I think you have to look at it, Senator Rockefeller, in two different ways. Yes, there is a proposal to cut those funds from the appropriated level of last year by 50 percent. But if you look at the way we construct a budget in the Department, with the constraints we have, the actual request is probably the same or up from last year showing, within that $160 million-odd budget request, the kind of priority that we place on liquid fuels.

Senator ROCKEFELLER. I like the sound of that, but I am not sure I quite understood it.

Mr. WAMPLER. If we had, for example, $400 million as a total for our request, the amount of liquid fuels would certainly be higher than it was the previous year, if we were at the appropriation mark.

Senator ROCKEFELLER. I understand.

Mr. WAMPLER. The numbers, Senator Rockefeller, are $39.65 million in request in 1989 and in 1990, the request is $56.48 million. So, as you see, within our allotment of funds for the request, we placed a great deal more priority on this issue than we had in the past.

Senator ROCKEFELLER. You did refer to a third of your cost savings being made up by four different programs on page 6, and one of those was, as you referred to, construction projects at West Virginia University and the University of Oklahoma. It cannot support continued funding for construction of administrative offices at Morgantown and Pittsburgh, et cetera.

Are you thereby telling us that it is only construction costs that are being cut and that there are no research or program costs that are being cut? And if you cannot answer that, could you have that answered to me in writing?

Mr. WAMPLER. I will furnish you that, specifically, for the record with all the cuts, but there are, in addition to those program areas, across-the-board cuts in research and development, indicated in the budget. But I will furnish you the specific amounts.

Senator ROCKEFELLER. Yes.

[The information follows:]

Budget Reductions at PETC and METC

PETC

Program	FY 1989 1/ Estimate B/A ($000)	FY 1990 Request B/A ($000)	Budget Reduction B/A ($000)
Control Technology and Coal Preparation	$30,394	$21,558	$- 8,836
Advanced Research and Technology Development	7,483	5,246	- 2,237
Coal Liquefaction	27,955	7,425	-20,530
Combustion Systems	12,306	6,549	- 5,757
Magnetohydrodynamics	16,200	0	-16,200
Program Direction	23,640	7,971	-15,669
Capital Equipment	232	0	- 232
Construction	3,338	1,896	- 1,442
Total Fossil Energy R&D	121,548	50,645	-70,903
Clean Coal Technology	10,433	3,747	- 6,686
Total Pittsburgh Energy Technology Center	$131,981	$54,392	$-77,589

1/ The funding in this exhibit covers current R&D operations at the Center and contracted work managed by the Center. The funding does not include pass through funds provided by the Center to National Laboratories and Operations Offices, nor prior year unobligated carryover.

METC

Program	FY 1989 Estimate B/A ($000)	FY 1990 Request B/A ($000)	Budget Reduction B/A ($000)
Control Technology and Coal Preparation	$ 14,647	$ 8,429	$ - 6,218
Advanced Research and Technology Development	2,613	5,570	+ 2,957
Coal Liquefaction	663	100	- 563
Combustion Systems	12,849	8,388	- 4,461
Fuel Cells	25,090	5,581	- 19,509
Heat Engines	22,360	8,741	- 13,619
Underground Coal Gasification	1,211	426	- 785
Surface Coal Gasification	19,445	8,562	- 10,883
Advanced Extraction and Process Technology	636	2,964	+ 2,328
Enhanced Oil Recovery	4,370	1,800	- 2,570
Oil Shale	6,920	1,649	- 5,271
Unconventional Gas Recovery	10,655	3,989	- 6,666
Program Direction	25,432	8,016	- 17,416
Capital Equipment	233	0	- 233
Construction	5,337	0	- 5,337
Total Fossil Energy R&D	152,461	64,215	- 88,246
Clean Coal Technology	27,588	4,155	- 23,433
Total Morgantown Energy Technology Center	$180,049	$68,370	$-111,679

1/ The funding in this exhibit covers current R&D operations at the Center, including costs associated with the operation of existing project offices at Grand Forks, North Dakota, and Laramie, Wyoming; efforts under the cooperative agreements with the University of North Dakota Energy and Mineral Resource Center and the University of Wyoming Research Institute; and contract work managed by the Center and project offices. The funding does not include pass through funds provided by the Center to National Laboratories and Operations Offices, nor prior year unobligated carryover.

Senator ROCKEFELLER. Do you agree that the time has come to take some of the research that has been done in clean coal technology and deploy it?

Mr. WAMPLER. Oh, I think absolutely so. If we don't make sure the technologies are deployed, we will end up with some interesting tour sites and very little else. I think that it is important, by whatever method, that these technologies deploy.

Senator ROCKEFELLER. Do you have any methodologies in mind?

Mr. WAMPLER. I think that, as you see the President's amendments to the Clean Air Act come to the Hill, you will see some incentives in those amendments to help this happen. It is something, I am sure, Congress will debate for quite a while after it sees it. But I think there are regulatory incentives that are properly out there that we can offer to clean coal demonstration projects.

Senator ROCKEFELLER. You have led right into my next question. In effect, then you do expect to see these incentives included in the Clean Air Act legislation.

Mr. WAMPLER. I do expect to see incentives in the legislation.

Senator ROCKEFELLER. The DOE's programs in fossil research and development that deal with matters unrelated to power generation are not clear to me. Are you in a position to describe the fossil R&D that is not related to power generation?

Mr. WAMPLER. I think there is quite a bit, and I will give you a couple of areas, Senator. Some of the liquid fuels programs are unrelated specifically to power generation. We have research, for example, in coal-fired diesels that is related to the transportation area. Those are just two examples that kind of stick out. We can certainly furnish you a complete list and a description if you would like.

Senator ROCKEFELLER. Coal as a feedstock.

Mr. WAMPLER. Coal as a feedstock, yes.

Senator ROCKEFELLER. Would you be willing to supply for the committee a list of those non-power generating R&D?

Mr. WAMPLER. Certainly.

Senator ROCKEFELLER. I would appreciate that.

[The information follows:]

FOSSIL ENERGY R&D NOT RELATED TO POWER GENERATION

A number of projects under the FE Atmospheric Fluidized Bed Combustion, Advanced Combustion Technology, Liquefaction, Heat Engines, and Surface Coal Gasification Programs are directed at developing systems that are not related to power generation. These systems are being designed to produce steam or process heat for application in the light industrial, commercial/institutional or residential sectors.

The following R&D projects listed under their respective FE programs are not related to power generation:

- o Atmospheric Fluidized Bed
  - Riley Stoker - Multi-Solids FBC
  - York Shipley - Vortexing FBC
  - Energy & Environmental Research (EER) - Air Cooled FBC
  - Management and Technical Consulting Inc. (MTCI) - Pulsed Bed FBC
  - Good Samaritan Hospital - Cofiring of hospital waste and coal in a circulating FBC
- o Advanced Combustion Technology
  - VORTEC - Coal-fired glass melting process
  - EER - Advanced coal-fueled combustor
  - MTCI - Pulsed coal combustion
  - Catholic University - Advanced vortexing coal combustor
  - TECOGEN - CWS-fired combustor
- o Coal Liquefaction

  None of the R&D in the Coal Liquefaction Program is related to power generation. Major projects in the program are:

  - Wilsonville - direct liquefaction proof-of-concept facility
  - LaPorte - indirect liquefaction proof-of-concept facility
  - Hydrocarbon Research Inc. - bench scale R&D
  - Amoco - bench scale R&D and catalyst research
  - UOP - bench scale R&D
- o Heat Engines

  General Electric coal-fueled diesel locomotive and Caterpillar coal-processed gas locomotive.

- o Systems for Production of Industrial Fuel Gas

  Research is directed toward the development of more economic and environmentally superior coal gasification systems to meet potential industrial feedstock and energy needs. The emphasis is on fundamental fluidization research, data analysis, and modeling and advanced instrumentation research.

- o Systems for the Production of Synthesis Gas

  Research is being directed toward the development of technologies for the low cost production of synthesis gas and hydrogen from coal. The emphasis is on producing hydrogen for use in direct liquefaction of coal to produce liquid transportation fuels.

- o Systems for the Production of Coproducts

  Research is being directed toward the development of new technologies based on low-temperature devolatization of coal in the absence of oxygen to produce a slate of value-added commercial coproducts for the transportation, chemical, and metallurgical industries.

Projects under the Alternative Fuels Program are for the most part crosscutting with potential application to all end use sectors. Specific projects that support in part nonpower related technology include:

- o Energy International - Characterize and supply fuel in support of the Advanced Combustion Technology Program

- o Combustion Engineering - Fuel and Fuel Combustion characterization of all beneficiated coal-based fuels

- o TBD - Handling, transport and storage of beneficiated coal-based fuels

Projects under the Coal Preparation Program are also crosscutting with potential application to all end use sectors and may be used to upgrade the feedstock for coal liquefaction, coal water slurries and other technologies.

Senator ROCKEFELLER. Thank you, Mr. Chairman. Those are all the questions I have.

Senator FORD. Senator Domenici.

Senator DOMENICI. Thank you, Mr. Chairman.

First, let me say to you, Secretary Wampler, I understand that this is your last appearance perhaps before this committee, and you will be leaving the Department soon. Is that correct?

Mr. WAMPLER. That's correct.

Senator DOMENICI. Mr. Chairman, I personally feel I would be remiss if I didn't say that I have been working with this Department since the first two years I was in the Senate, I wasn't on this committee—so, that means 14 and a half years. And I do not have any difficulty saying that in the field of fossil fuel I believe this Secretary has been the most effective. And I want to congratulate you. You have in very difficult times in my humble opinion done an outstanding job.

I personally am sorry to see you leave. I guess that is the way things happen. I hope you have enjoyed the last year and a half or so. I sense it has been a rather exciting time for you.

Having said that, might I ask you what do we know about coal technology on the side of clean coal technology and its possible development out there in the rest of the world? Maybe putting it more simply, are we with the monies we are spending on the leaders in clean coal technology development as you see it?

Mr. WAMPLER. I think clearly we are. I think we started the process as we went into Round 1 of clean coal technology with a very slight competitive edge. I think that with the amount of money that we are spending, and clearly with the $5 billion plus that will be spent, we will emerge during the next five years as the clear leader in the world in clean coal technology.

Senator DOMENICI. Mr. Secretary, moving now to the domestic side for a minute, with reference to the President's acid rain cleanup proposal, on the time frame that we are being asked to implement a reduction of acid rain, how helpful has the clean coal technology research program been with reference to that?

Mr. WAMPLER. I think it has been very helpful, and I think it will prove to be extremely helpful. If you look at the technologies that existed prior to clean coal technology, or at least were in the demonstrated form, we are dealing principally with scrubbers. Scrubbers do a job, but produce some collateral effects that you certainly do not want in the form of wet sludge, increased carbon dioxide, those kinds of things.

I think that it is imperative. And the value of the Clean Coal Technology Program is that we set up a structure in which these technologies, the first of their kind in the demonstration phase, can be demonstrated and the utilities will have enough confidence in them to deploy them on a widespread basis.

Senator DOMENICI. So, you believe that there are some technologies already far enough along that even in the first phase of the President's acid rain reduction, they will add some flexibility to the cleanup effort that he recommends?

Mr. WAMPLER. I think clearly that we have some retrofit technologies that will.

Senator DOMENICI. It is true, however, that to get the maximum effect, we will have to wait into the next phase and perhaps have the best effect in the second ratchet down of acid rain in the President's proposal.

Mr. WAMPLER. Yes. Unfortunately, the repowering technologies that get you 99.5 percent reduction in SO_2 are the ones that start being available for deployment around the year 2000 and beyond.

Senator DOMENICI. With reference to an allocation of the matching grants, I just want to reemphasize the position taken by the distinguished Senator from Colorado and repeat the request that you submit what you are going to do with reference to the western part of the United States in terms of some of this technology development. I believe it has been pretty skewed in the first phase. I gather that some effort is going to be made to be a bit more national in scope in the second phase. Is that correct?

Mr. WAMPLER. Yes, we have made a great deal of effort and Secretary Watkins has indicated very strongly that he is in favor of wide geographic distribution to all resources.

Senator DOMENICI. My last question has to do with the question of greenhouse. Perhaps I could state it my way and ask you if you know enough about this issue to at least venture some information.

It seems to this Senator that while we can go ahead and ratchet down as much as we want with reference to our concern about the greenhouse effect, that the truth of the matter is whatever we save is going to be inconsequential as compared with the next 20 to 25 years in what the third world and developing countries are going to produce by way of CO_2 and NO_x. It seems inevitable to me with the huge population increases in those countries, that they are not going to be satisfied without the material wealth and the growth that we have recommended to this world and set the example for. And the building block to that is energy.

It seems to me also that they are going to burn whatever energy they need whether it is the dirtiest coal around or whether it is wood. They are going to build their material wealth base. And I do not believe it takes much modeling to say that is going to produce far more CO_2 and NO_x than we are ever going to be able to reduce and ratchet down in the United States even though we are one of the biggest sources now.

It seems likewise to me that the most logical thing for us to do is to join with other developed industrialized nations to make a commitment to the third world nations that we will help them develop cleaner methods of producing their energy and perhaps even finance in an international way their energy production and transfer our technology since they do not have it. A perfect example is China. China will produce more CO_2 and NO_x in burning dirty coal in the next 20 years under their current development than we will ever reduce.

My thought is that the United States ought to take this technology and its leadership and move into that area for two reasons: the one I just stated, and the other is if we do not do that, the finger will be pointed at us as the chief current producer of the pollutant. And we can only ratchet down so much without changing dramatically our standard of living.

Might I ask do you have any thoughts on that subject and is anything being done in the Department that you are aware of?

Mr. WAMPLER. Well, I totally agree with your assessment. I think anyone that thinks that the world will continue and develop without the burning of fossil fuels is pretty naive. It just is not going to happen.

I think you are also right that we have a responsibility, being leaders in the technology, to share these technologies with the third world. As to what is being done, we, for the past several months and perhaps a year, have had a program under way that we call our LDC initiative in which we have taken a look at several Less Developed Countries to assess the opportunities for clean coal technologies and coal export to those countries.

We signed, just a month ago, an agreement with Costa Rica to work with them on a power project that would use the clean coal technology.

The President yesterday announced that we would be working with Poland on a clean coal technology project there.

But we have been to countries like Thailand. We have been all around the globe to assess opportunities, and we intend to do more of that. I think that it is very important that that whole effort be accelerated. And I think that you will find that Admiral Watkins is convinced of the same thing and will be very receptive to that.

Senator DOMENICI. Where jurisdiction-wise, if any, would that fit within the Department of Energy? Is it fossil fuels or in the international?

Mr. WAMPLER. The coal export initiative was shared, jurisdictionally by International and Fossil Energy, the effort being chaired by Fossil Energy. And it is an effort also that we have worked on with the Department of Commerce, the TDP, OPIC, the State Department and others to make sure the whole Administration was involved in this effort.

Senator DOMENICI. My last question has to do with the issue of coordination of greenhouse research and evaluation. You are aware, are you not, that jurisdiction over greenhouse research is in many departments of the Federal Government? Is that not right?

Mr. WAMPLER. That's true.

Senator DOMENICI. My recollection, the President's budget, even though some people think we are doing little or nothing—my recollection is there are $190 million in research and assessment money spread in five different departments of the Federal Government on greenhouse science.

Mr. WAMPLER. At least that, yes.

Senator DOMENICI. There is some kind of coordinating mechanism. Do you have an impression at this point? You know, you are leaving, so you can be honest. [Laughter.]

Senator FORD. Oh, come on.

Senator DOMENICI. Excuse me. That didn't sound right.

Senator FORD. I have found that he has been disagreeable on occasion, but not dishonest. [Laughter.]

Senator DOMENICI. No. Let me put it this way.

Senator FORD. Ask him what he feels.

Senator DOMENICI. Yes. We would be very interested in how you feel, if you have any strong feelings.

Could we do a better job in your opinion of coordinating the kind of resources that are there? I know they are over in EPA. They are in the weather surveillance department of the government. They are in the Department of Energy. I believe they are over in Interior, and I can't remember the fifth one.

Senator HEFLIN. NASA.

Senator DOMENICI. NASA.

Mr. WAMPLER. I think clearly we could do a better job and I think clearly a better job will be done. If you look at the greenhouse issue, it is an issue that came on the scene very quickly and accelerated even quicker than that. And it is one that still hasn't been totally worked out. I put a good deal of confidence in the Domestic Policy Council and I feel that it ultimately will be the one that gets involved and makes a determination on the whole process.

I think that we do have some very conflicting scientific evidence on this issue. I hear, on the one hand, some experts, that I have a lot of confidence in, say there is simply no correlation between CO_2 and temperature. It is more a correlation of sun spots and temperature. And, on the other hand, we have the other side of the story. So, there are clearly some uncertainties, and the politics of this situation I'm afraid are driving it more rapidly than the science. And I think that we have to get that under control.

Senator DOMENICI. On the other hand, it doesn't make too much difference where those scientists will end up if we don't work on the world and the production of CO_2 and NO_x. As the population is going to double and the use of energy is going to triple and quadruple, it makes sense to go ahead and try to ratchet that down in cooperation whether we know all the answers to greenhouse or not. Isn't that correct?

Mr. WAMPLER. It is an international problem, and there has to be an international answer to it.

Senator DOMENICI. Thank you, Mr. Chairman.

Senator FORD. Thank you.

I might say that I guess the Secretary was referring to the recent statement about the hot spots and that the 1980s are the hottest decade. Then we have to realize that the 1970s was the coolest decade. So, the minority is very substantial individuals with a great deal of background.

Senator McConnell.

Senator MCCONNELL. Thank you, Mr. Chairman.

I'll stay on this area just a bit because that was the area that I had planned on covering. Senator Domenici has covered most of it. You may have answered this, but which countries do we compete with, if any, in the field of exporting clean coal technologies? Who else is active in this area?

Mr. WAMPLER. Our major competitors are Germany, Japan, and, to some extent, Sweden. We still do have a competitive edge.

Now, some of the technologies that we are demonstrating in the Clean Coal Program contain technologies from those countries. As a matter of fact, there are cooperative projects. And that is something we are looking at very carefully. I think we want to make sure that we maintain a competitive edge in this program.

Senator McCONNELL. But you are not really sure that we do have. You say that we are looking at——

Mr. WAMPLER. We do have a competitive edge in terms of what technology exists and the amount of money that we are spending on the technology. And the unusual, unique relationship we have with the private sector and the government in this is a very strong relationship. I am very confident that that is going to keep our competitive edge. But I think we have to be very watchful of the kinds of deals that we strike with the other countries in these technologies to make sure that we keep that competitive edge. It is an issue we are currently looking at very hard.

Senator McCONNELL. I guess unrelated to the environmental issue, I wonder if any studies have been done about what kind of impact this could have the merchandise trade deficit.

Mr. WAMPLER. I am not aware of any. We have done some back-of-the-envelope studies on it that I think are fairly good. We would be glad to furnish those to you.

Senator McCONNELL. I would be interested.

Mr. WAMPLER. It's a massive amount of money.

Senator McCONNELL. This could be a pretty important business for America if we could maintain our edge, could it not?

Mr. WAMPLER. It certainly could, the export of technologies and, coupled with that, the export of coal. And we feel the technologies are going to give us a real edge up on the export of the coal that has been demonstrated by these technologies. It could have perhaps the single most dramatic impact on the balance of trade of any commodity that we are dealing with.

Senator McCONNELL. Is that correct?

Mr. WAMPLER. Very, very large. If further studies prove the back-of-my-envelope calculations, that, indeed, is true. But we will furnish you some information on that.

[The information follows:]

COAL EXPORT AND TECHNOLOGY

Studies performed on increasing exports of coal and coal technologies to foreign countries are listed below, and copies of completed reports are provided. The potential impact of increased coal and coal technology exports by the year 2000 could impact the U.S. trade deficit on the order of up to $27 billion per year based on industry projections.

Published Studies:

- Potential markets for small coal-fired combustors in OECD countries: Country Screening
- The Coal Logistics System
- U.S. Fossil Fuel Technologies for developing countries: Costa Rica Country Packet
- U.S. Fossil Fuel Technologies for developing countries: Thailand Country Packet
- Summary technology characterization report, International Summary Update 4
- U.S. Fossil Fuel Technologies for developing countries: Proceedings public meeting July 21, 1988
- The International Marketplace - Niches for U.S. Coal Technology: Proceedings public meeting October 3, 1988

Reports in Process:

- Industry Directory of U.S. Coal and Coal Technology and Related Companies and Organizations
- Guide to U.S. Federal Coal and Coal Technology Export Assistance Programs
- Innovative Coal Transportation
- Potential Markets for small coal-fired combustors in Italy, Spain and Turkey

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Committee Note.--The copies of the reports provided have been retained in subcommittee files.

Senator MCCONNELL. Getting back to the area Senator Ford was touching on, is it your view that the year 2000, which seems to have become the rather magic year, is an achievable year for the clean coal technologies that have the greatest potential?

Mr. WAMPLER. I think the year 2000, with the extension that you will see proposed by the Administration, will be, but I think it will be tight. I think we have to admit that. I think that is why we have to be very watchful in Rounds 4 and 5 of the way we structure those two rounds of demonstration. We are going to have to look at possible ways to accelerate. We are going to have to all debate the incentives to see if they are sufficient to get these technologies deployed. It is tight, but I think it is achievable.

Senator MCCONNELL. Will those dates also keep us well ahead of our competitors in terms of the export of clean coal technologies?

Mr. WAMPLER. They certainly will.

Senator MCCONNELL. So, this whole area has enormous potential both environmentally and in terms of business.

Mr. WAMPLER. It has incredible potential.

Senator MCCONNELL. If you were writing the budget and didn't have to worry about the kinds of financial constraints that we have, would you be putting a heck of a lot more into this area than we are?

Mr. WAMPLER. In the Clean Coal Technology Program itself, I think that the $2.5 billion is about all——

Senator MCCONNELL. All we can absorb usefully?

Mr. WAMPLER [continuing]. We can absorb with the private sector. I would certainly be interested to hear some of the private sector witnesses on that matter.

Senator MCCONNELL. So, you don't think we are scrimping on this then.

Mr. WAMPLER. Not in the Clean Coal Technology Program itself. I think you could make the argument that we certainly have proposed budgets that did scrimp on the R&D that feeds into the pipeline on this. But, in the Clean Coal Technology Program itself, I think there is sufficient funding, if the advanced appropriations are approved and the money is forthcoming.

Senator MCCONNELL. Given the environmental impact and your envelope calculations about the impact on the trade deficit, I think one could pretty safely conclude this is certainly not an area to scrimp, is it?

Mr. WAMPLER. No, it is not an area. It is an area that could become very important to us economically. It is very important to us.

Senator MCCONNELL. I think that essentially covers what I was mostly interested in unless you have some other just random thoughts about this export issue while we are on it that Senator Domenici or I may not have asked you.

Mr. WAMPLER. I think you pretty well covered it. I think that, for this to be successful, the one thing I've learned—after going through a very difficult learning experience on this whole thing in starting the export initiative—is that it is going to take the cooperation of several departments in government to pull this off successfully. And I hope that that support and cooperation is forthcoming.

I think the whole export initiative is going well now, after some rough starts and some very natural turf battles. It was something that was not unnatural at all that we have those. But this issue is important enough I think that that kind of cooperation is certainly warranted.

And I see great things happening both in developing nations and in more developed nations for the use of coal technology, particularly the high efficiency coal technologies which have both an impact on CO_2 and sulfur dioxide, all the emissions. Those are the ones that can become very, very attractive to developing nations.

Senator MCCONNELL. Thank you, Mr. Chairman.

Senator FORD. Senator Heflin.

Senator HEFLIN. Mr. Chairman, I have an opening statement that I will submit for the record.

Senator FORD. It will be included in its entirety.

[The prepared statement of Senator Heflin follows:]

OPENING STATEMENT

SENATOR HOWELL T. HEFLIN

SENATE SUBCOMMITTEE ON

ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND

NATURAL RESOURCES

HEARING ON DOE FY '90 FOSSIL
ENERGY BUDGET
AND
RELEVANT PROVISIONS OF S.964

WASHINGTON, D.C.

JULY 11, 1989
2:30 P.M.

MR. CHAIRMAN:

I AM DELIGHTED THAT WE ARE HOLDING A HEARING ON THE DOE FY '90 FOSSIL ENERGY BUDGET AND THE RELEVANT PROVISIONS OF S.964, THE ADMINISTRATION'S BILL TO AUTHORIZE APPROPRIATIONS TO THE DOE FOR CIVILIAN ENERGY PROGRAMS FOR FY '90 AND '91.

IT IS MY UNDERSTANDING THAT THE DOE R&D EFFORT IS FOCUSED ON PROJECTS THAT DOE BELIEVES ARE TOO HIGH-RISK OR LONG-TERM FOR THE PRIVATE SECTOR TO CONDUCT. IF MY UNDERSTANDING IS CORRECT, MR. CHAIRMAN, HOW CAN DOE ASK FOR A PALTRY $163.6 MILLION IN FY '90 FOR FOSSIL ENERGY RESEARCH AND DEVELOPMENT -- A ROUGHLY 233% REDUCTION OF OR $217 MILLION LESS THAN THE FY '89 APPROPRIATIONS OF $381.6 MILLION. IT IS ALSO A 258% REDUCTION OF OR $259 MILLION LESS THAN THE $422.6 MILLION RECENTLY APPROVED BY A HOUSE PANEL IN ITS FY '90 INTERIOR APPROPRIATIONS BILL (H.R. 2788, H. REPT. 101-120).

I WAS GREATLY DISTURBED TO LEARN THAT THE DOE HAS NOT RECOMMENDED ANY FUNDING FOR THE WILSONVILLE COAL LIQUEFACTION TEST FACILITY, LOCATED IN MY HOME STATE OF ALABAMA. IN TALKING TO THE APPROPRIATE OFFICIALS AT THE SOUTHERN COMPANY WHO RUN THIS TEST FACILITY, DOE AND THE SOUTHERN COMPANY ARE IN THE MIDDLE OF A 3-YEAR CONTRACT.

IT IS MY UNDERSTANDING THAT RECENT DEVELOPMENTS AT WILSONVILLE HAVE SHOWN THAT AS MUCH AS 78 PERCENT OF LOW-ASH, HIGH-CARBON EASTERN BITUMINOUS COALS CAN BE CONVERTED INTO DISTILLATE FUELS. IN ADDITION, REVISED ESTIMATES OF THE ECONOMICS OF DIRECT COAL LIQUEFACTION TECHNOLOGIES SHOW THAT THE COST OF PRODUCING COAL-DERIVED LIQUIDS HAS BEEN REDUCED FROM $93 PER BARREL IN 1983 TO $40 PER BARREL IN 1988 THROUGH IMPROVEMENTS IN TECHNOLOGY AND PLANT DESIGN.

IT IS ALSO MY UNDERSTANDING THAT THE GOAL OF CONTINUED COAL LIQUEFACTION RESEARCH AT WILSONVILLE OVER THE NEXT YEAR IS TO REDUCE THE COST OF COAL-DERIVED LIQUIDS FROM THE CURRENT $40 PER BARREL BY AT LEAST ANOTHER 20 PERCENT TO $32 PER BARREL. IF COAL-DERIVED FUELS CAN BE PRODUCED FOR $32 PER BARREL, THERE IS A REASONABLE POSSIBILITY OF COMMERCIALIZING DIRECT LIQUEFACTION BEFORE THE NEXT OIL CRISIS OCCURS. IF COAL LIQUEFACTION CAN BE COMMERCIALIZED UNDER NON-CRISIS CONDITIONS, THE PRICE THE UNITED STATES HAS TO PAY FOR IMPORTED OIL WILL BE EFFECTIVELY CAPPED. COMMERCIALIZATION CAN ALSO HELP REDUCE THE TRADE DEFICIT BY

REPLACING IMPORTED OIL WITH FUELS PRODUCED FROM THE DOMESTIC COAL RESERVES.

IT IS FURTHER MY UNDERSTANDING THAT RESEARCH AT THE WILSONVILLE COAL LIQUEFACTION TEST FACILITY, IF CONTINUED NEXT YEAR, WOULD FOCUS ON:

* LOW-ASH, HIGH-CARBON EASTERN BITUMINOUS COALS TO INCREASE THE QUANTITY OF DISTILLATE YIELDS.

* IMPROVED CATALYSTS TO LOWER CAPITAL AND OPERATING COST, INCREASE DISTILLATE YIELDS, AND IMPROVE PRODUCT QUALITY.

* IMPROVED PROCESS CONFIGURATIONS TO LOWER CAPITAL AND OPERATING COSTS.

IF THE WILSONVILLE PROJECT IS TERMINATED BEFORE THE GOALS ARE COMPLETED, MOST OF THE MONEY SPENT AND RESULTS DEVELOPED WOULD BE WASTED. IN ADDITION, THE GOVERNMENT, CONCEIVEABLY, WOULD HAVE TO SPEND $30 TO $50 MILLION DURING THE NEXT OIL CRISIS TO BUILD AND OPERATE A SIMILAR FACILITY TO COMPLETE THE DEVELOPMENT OF THE TECHNOLOGY. MORE IMPORTANTLY, IT WOULD TAKE AT LEAST FIVE YEARS TO RE-LEARN THE OPERATING AND MAINTENANCE TECHNIQUES THAT ARE PRESENTLY WELL UNDERSTOOD AT WILSONVILLE.

WITH REGARD TO THE CLEAN COAL TECHNOLOGY PROGRAM, MR. CHAIRMAN, I HAVE SOME QUESTIONS FOR MR. WAMPLER, WHICH I'LL SUBMIT TO HIM IN WRITING. I WOULD LIKE FOR HIM TO RESPOND TO THEM IN WRITING IN A TIMELY FASHION.

I WOULD LIKE TO MENTION HERE, MR. CHAIRMAN, THAT ON JUNE 5, 1989, YOU, SENATORS JOHNSTON, BYRD, MCCLURE, NICKLES

AND I SENT A LETTER TO PRESIDENT BUSH PRIOR TO THE ANNOUNCEMENT OF HIS CLEAN AIR ACT AMENDMENTS. IN THAT LETTER WE URGED HIM TO USE CAUTION TO ASSURE THAT NOTHING PROPOSED IN ACID RAIN LEGISLATION ADVERSELY IMPACTS THE DEVELOPMENT OF CLEAN COAL TECHNOLOGIES OR JEOPARDIZES THE VERY SIGNIFICANT FINANCIAL INVESTMENT ALREADY MADE BY THE GOVERNMENT AND INDUSTRY. AT A MINIMUM, WE URGED THE PRESIDENT THAT HE INCORPORATE INCENTIVES, A SUFFICIENT PERIOD OF TIME BEFORE MANDATED REDUCTIONS TAKE EFFECT, AND SUFFICIENT FLEXIBILITY, SO AS TO ALLOW FOR THE UTILIZATION OF THE FULL RANGE OF CLEAN COAL TECHNOLOGIES.

FINALLY, MR. CHAIRMAN, ON THE ISSUE OF EASTERN OIL SHALE, ON JUNE 9, 1989, I WROTE A LETTER TO SENATOR BYRD, CHAIRMAN OF SENATE APPROPRIATIONS AND CHAIRMAN OF THE SUBCOMMITTEE ON INTERIOR APPROPRIATIONS EXPRESSING MY STRONG SUPPORT FOR TWO ENERGY PROGRAMS BEING CONSIDERED BY YOUR SUBCOMMITTEE IN YOUR DELIBERATIONS ON FY "90 APPROPRIATIONS:

--$8.0 MILLION FOR EASTERN OIL SHALE RESEARCH, AND

__$1.0 MILLION FOR COAL BED METHANE RESEARCH.

THE MINERAL RESOURCES INSTITUTE (MRI) AT THE UNIVERSITY OF ALABAMA IS AN ACTIVE PARTICIPANT IN THESE PROGRAMS. I HAD THE PRIVILEGE OF ACTING AS TEMPORARY CHAIR OF SENATOR BYRD'S SUBCOMMITTEE HEARING ON FEBRUARY 9, 1989, WHEN DR. BRUCE TIPPIN, DIRECTOR, MRI, UNIVERSITY OF ALABAMA, TESTIFIED IN SUPPORT OF THE EASTERN OIL SHALE PROGRAM.

MR. CHAIRMAN, AS YOU CAN TELL, I ALSO STRONGLY SUPPORT CONTINUED FUNDING OF THE EASTER OIL SHALE PROGRAMS.

THANK YOU.

Senator HEFLIN. First, I have some questions I want to submit in writing to cut down on the time dealing with clean coal technology. Some of them probably have been answered, but if you will, we would appreciate if the witness would respond.

Senator FORD. They will be submitted to the Department.

Senator HEFLIN. And we would like to request that you review those. There is always a danger in submitting anything in writing. The answers usually are drafted by an expert in the bureaucracy who believes in linguistic gymnastics and legalistic——

Senator FORD. Is that what you call a word merchant? [Laughter.]

Senator HEFLIN. We would appreciate your giving us answers in keeping with the already proclaimed honesty that you have through the Chairman and others.

Talking about clean coal technology and talking about the fossil energy research, it seems to me that this time DOE in the budget is asking for $163 million in the 1990 budget and this is roughly a 233 percent reduction or $217 million less than the fiscal year 1989 appropriation of $381 million. Can we with all of the problems that we have with acid rain and the environmental issues—is this a wise decision to make, to cut back substantially on fossil fuel research and development?

Mr. WAMPLER. Let me answer that this way, since Senator Domenici pointed out I can be honest. I have always tried to be honest in these hearings.

Senator FORD. Be frank then.

Mr. WAMPLER. The budgets that we have submitted for the past eight years and the ones that I have been personally involved in for the past three—you have to count them in terms of fiscal problems that we all had. You have to count them in terms of the fact that the stated purpose of the Reagan Administration was to shut the Department of Energy down. There is some of that in there. So, they have been incredibly lean budgets.

If you ask me to give you an honest answer as to whether I could have taken $150 million and run a balanced research and development program in fossil energy, yes, I think I could have, but I would have had to cut personnel fairly dramatically. I would have had to cut out all the luxuries. Federal employees would have had to work like they have never worked before.

And we could have had a somewhat balanced kind of a program. But I think what you are going to see now—and it is already taking place in the Department—by the way, another thing that really affected the R&D during the past several years was the fact that we always insisted on looking at long-term, high risk R&D and not addressing the short-term to mid-term.

You are seeing a very healthy thing happen now, in my opinion. You are seeing the budget planning process for this next year looking at the short-term, mid-term and long-term. I think you are going to see a fairly substantial change. This is going to be certainly up for debate, as it should be within the Administration as to who gets a share of what. That is very proper because, I guess, my colleagues in Congress do it all the time. But I think you are going to see a different look at that budget. I know that in the process that I have been involved in up to this point, we are looking at it

in a very different way, in terms of effectiveness, competitiveness and those kinds of things. Since we have all determined that President Bush has been very strong about saying the Department of Energy is here to stay, I think you are going to see a different look at that.

I am sorry for the long-winded way I took to answer your question.

Senator HEFLIN. Let me now get to something that affects my state. It is my understanding that in this Wilsonville coal liquefaction plant, that they are in the middle of a three-year contract. And yet the testimony is that work is successfully concluded this year.

It is my understanding that recent developments at this Wilsonville liquefaction plant for coal, as much as 78 percent of the low ash, high carbon eastern bituminous coal can be converted into distilled fuels.

And in addition, revised estimates of the economics of direct coal liquefaction technologies show that the cost of producing coal-derived liquids have been reduced from $93 per barrel in 1983 to $40 a barrel in 1988 through improvements in technology and plant design.

It is also my understanding that the goal of continued coal liquefaction research over the next year is to reduce the cost of coal-derived fuels from the current $40 per barrel by at least another 20 percent to $32 per barrel. If the coal-derived fuels can be produced for $32 per barrel, there is a reasonable possibility of commercializing direct liquefaction before the next war crisis occurs. And, of course, also as further research goes on, it is possible to reduce the cost down even substantially more than the $32 a barrel.

If coal liquefaction can be commercialized under non-crisis conditions, the price that the United States might have to pay for imported oil can be effectively capped. Commercialization can also help reduce the trade deficit by replacing imported oil with fuels produced from the domestic coal reserves.

Further, my understanding that research on coal liquefaction, if continued next year, particularly this Wilsonville plant, would focus on low ash, high carbon eastern bituminous coals to increase the quantity of distilled yields and also improve catalysts to lower capital than operating costs increasing distilled yields and improve product quality, improve process configurations to lower capital and costs.

It seems to me that if this project is terminated, most of the money spent and the results developed would be wasted. In addition, the government conceivably would have to spend $30 million to $50 million during the next oil crisis to build and operate a similar facility to complete the development of the technology. More important, it would take at least five years to relearn the operating and maintenance techniques that are presently well understood at Wilsonville. So, I hope you will take a look at that again.

Is it correct that you are in the middle of a three-year contract?

Mr. WAMPLER. We have completed—I am not aware of being in the middle of a three-year contract.

Senator HEFLIN. You've got another year and a half. If you cut out the money now, it is going to cut that contract out.

Mr. WAMPLER. There is other work, you are right, that could be done. We have completed a phase of the demonstration.

You are also right on the numbers. Our latest economic indicators on this facility indicate that we are looking at $30 to $35 a barrel, which is pretty good.

Wilsonville is one of these projects that I put in my category. Just because it was not funded, it is not necessarily a bad project. Had there been more money available for the budget, Wilsonville would have been a strong candidate for that funding.

There are two things, though, that you have to realize about Wilsonville. Wilsonville is about an $8.4 million project in terms of operational costs per year, and that is a little bit high. Some of our researchers have made suggestions that we can do some research at bench scale that will get us the next step in our lowering of price for that synthetic fuel. That is something that could be looked at. I frankly have not looked at that.

One important thing that we are doing, Senator Heflin, is we have never in the Department had a common economic analysis on alternative fuels to price them out. We have used different indicators, different economic assumptions. We now have the National Academy of Sciences taking a look at that, and they will be finished by August or September with their look at these price scenarios. I think that will be very important information.

But Wilsonville is simply one of those operations that had there been money available, we would have funded the project.

Senator HEFLIN. It seems to me there are potential problems that would arise by terminating it, and it ought to be continued. I hope you all will take another look at that.

That's all.

Senator FORD. Fine. Thank you, Senator Heflin.

Does any other Senator have any questions?

Senator ROCKEFELLER. Mr. Chairman, I just have one.

Senator FORD. Senator Rockefeller.

Senator ROCKEFELLER. It was not clear to me that the Secretary was really amplifying precisely what it is that is being done in terms of the exporting of clean coal technology. Senator McConnell and Senator Domenici I believe asked a number of questions on that, but I wasn't really clear what it is that you are actually doing to enhance exports.

Mr. WAMPLER. Specifically we have brought together a multiagency group within the Federal Government, the State Department, TDP, the Department of Energy, and the Department of Commerce, and have set up a committee to take a look at the Less Developed Countries and other countries. We have started, throughout those countries, doing feasibility studies on the appropriateness of clean coal technologies for their particular power plant configurations.

For example, we are in the process now of cataloging every power plant in Italy to see what clean coal technologies would be applicable to those power plants. We have done this in Less Developed Countries such as Costa Rica, the Dominican Republic, Thailand, and some others that I don't recall right now. But that has been a massive effort to do feasibility studies.

The next step is to bring the private sector together a little bit better, architects, engineers, coal companies, those kinds of groups, to let them know what the opportunities are in these countries. We have had one meeting in which we described a couple of countries, told the private sector to take the information that we had back, and tell us if it was the kind of information they needed to penetrate that market. Those comments are in the process of being made, and there should be several more follow-up meetings to that.

The real purpose is to get the private sector working with the governments and for the government to pave the way, government-to-government, with some of these countries to provide an entree for the private sector. That specifically is what we are doing.

Senator ROCKEFELLER. Would you be able to supply a list to the committee of the number of countries with which you are working in this regard?

Mr. WAMPLER. Sure.

[The information follows:]

CO-OP AGREEMENTS WITH FOREIGN COUNTRIES

DOE is working with a number of countries to promote the export of coal and coal technology under several types of agreements and arrangements and these are listed below:

General Technical Cooperation Arrangement for Deployment of Clean Coal Technologies:

- Costa Rica
- Chile
- Thailand

Cooperative R&D Agreements:

Bi-Lateral

- Australia
- Brazil
- Canada
- Finland
- India
- Israel
- Italy
- Japan
- Korea
- China (PRC)
- United Kingdom
- Venezuela

Multi-Lateral

- Australia
- Austria
- Belgium
- Canada
- Denmark
- Finland
- Germany (FRG)
- Japan
- Netherlands
- New Zealand
- Spain
- Sweden
- United Kingdom

In addition to the above lists DOE is also working with the Dominican Republic, Indonesia, Pakistan, and Turkey.

Mr. WAMPLER. In addition to that, Senator, we have, as I recall, 49 international agreements—47 or 49—with both developed and less developed countries that call for joint research and development. We are taking a look at every single one of those agreements now to see if we can leverage coal exports by the use of those agreements. We have been very successful in doing that with Italy, for example, and we think there is a lot more opportunity out there for that.

Those are the two basic things.

Senator ROCKEFELLER. Thank you.

Senator FORD. Does anybody else need a parting shot?

[No response.]

Senator FORD. Mr. Secretary, we thank you for your efforts during the past years and wish you every success in the future. We appreciate your coming today.

Mr. WAMPLER. Thank you very much.

Senator FORD. Next we will have a group of four which will be a panel of witnesses. We ask that they come forward. Mr. R.E. Disbrow, President and Chief Operating Officer, American Electric Power Service Corporation, on behalf of the Clean Coal Technology Coalition; David O. Webb, Senior Vice President, Policy and Regulatory Affairs, Gas Research Institute; Dr. Thomas G. Squires, Past President, Fuel Chemistry Division, American Chemical Society; and Leonard K. Peters, Vice Chancellor for Research and Graduate Studies, University of Kentucky. Gentlemen, won't you please come to the head table?

We will start with you, Mr. Disbrow.

STATEMENT OF R.E. DISBROW, PRESIDENT AND CHIEF OPERATING OFFICER, AMERICAN ELECTRIC POWER SERVICE CORP., AND ON BEHALF OF THE CLEAN COAL TECHNOLOGY COALITION

Mr. DISBROW. Yes, thank you, sir.

Mr. Chairman, members of the subcommittee, I am Richard E. Disbrow, President and Chief Operating Officer of the American Electric Power Service Corporation. I am testifying today on behalf of the Clean Coal Technology Coalition for which I am currently serving as chairman.

I have been asked to comment upon DOE's clean coal program, but I would also like to address the possible interaction of the administration's statement of principles regarding possible acid rain legislation and the clean coal program.

It should be obvious that any realistic national energy policy, and in particular with regard to electric power, should rely heavily on our most abundant, indigenous energy resource, coal. However, there are concerns with respect to the environmental acceptability of continuing or expanding the usage of coal. In keeping with this, the clean coal program is directed at perfecting new technologies that will employ coal in a more environmentally acceptable manner.

Following a joint meeting of the special envoys from Canada and the United States, our government proposed a $5 billion research and development program in furtherance of clean coal technologies

to be jointly funded by government and the private sector. Since 1985 Congress has appropriated some $1.5 billion on this behalf, and the administration is currently requesting an additional $1.2 billion.

DOE has had three rounds of clean coal solicitations. While the actual amount of private sector co-funding is not yet known for the third round, it is believed that the aggregate of all three solicitations should be approximately $2.5 billion. This means that industry will invest $5 for every $3 of government funding.

Contrary to the views expressed by some on the subcommittee, I believe DOE has done a fine job of selecting appropriate projects to date, and I see no reason why this record will not continue as Round 3 is concluded or in Rounds 4 and 5, if the request for the further $1.2 billion is accepted.

The foregoing is not to say that some adjustments to the ongoing clean coal program are not warranted, however. I believe the following changes should be considered and these relate to, number one, recoupment of the government money; two, incentives for deployment; and three, safe harbor provisions.

It is apparent the Congress intended the government's share of clean coal funding be a grant rather than a loan. Yet in all three DOE solicitations, recoupment of the government money has been required. Now, admittedly the third round requirement has been sharply relaxed, but regardless, recoupment remains a problem and a discouragement.

Equipment vendors who participate in the government's clean coal program have already invested substantial sums in R&D and are not inclined to face a further economic burden and to be disadvantaged when competitors can potentially replicate the technology at lower overall cost.

Neither are utilities in a position to pay back the government. Most major projects require a utility host, and even with co-funding, the utility must seek recovery of substantial sums from rate regulators. This is a substantial risk in itself, but the risk is compounded if repayment of the government's share were to become necessary. Moreover, it should be noted that the government grants are an encouragement to state regulators to permit recovery of the utilities' direct investment. So, from a utility perspective, I would urge that recoupment be waived unless recoupment is supported by rate regulators through rate regulatory actions.

Accelerated development and subsequent widespread deployment of these emerging———

Senator DOMENICI. Mr. Chairman, might I ask a question on just that point?

Senator FORD. Yes.

Senator DOMENICI. I did not understand that. Why would the regulators be more prone to permit recoupment when there is a grant—permit inclusion in the rate base when it is a grant than when there is recoupment? It seems to me it would be the opposite.

Mr. DISBROW. No, sir, I would disagree because the regulators are interested in the rates charged to consumers. And if it is a grant, that amount of money will not be charged to consumers. That would be more encouragement to them to allow the residual part, the utility part, to be recovered through rates. Of course, if it is a

loan, then the entire amount would have to be recovered through rates and they would be less inclined to go along with it in my opinion.

Senator DOMENICI. I understand.

Mr. DISBROW. Accelerated development and subsequent widespread deployment of these emerging technologies would benefit most from adoption from regulatory incentives and removal of regulatory impediments.

President Reagan's task force chaired by then Vice President Bush made a series of recommendations for change, changes to existing regulations to stimulate clean coal technology development. Those recommendations accepted in January 1988 have not yet been implemented, and similar proposals were recommended to the Secretary of Energy by the National Coal Council and the Innovative Control Technology Advisory Panel. These too have not been acted upon.

On a related regulatory issue, there is widespread concern within the utility industry over the recent decision of EPA concerning a proposed power plant rehabilitation project proposed by Wisconsin Electric Company, or WEBCO. A full explanation is attached to my written statement. But the essence of the decision is that if a decision is applied to a project to demonstrate a clean coal technology at an existing plant, that plant may then be subjected to a new source performance review as well as other environmental review, and as a consequence, the plant may be required to meet stricter emission requirements than if nothing had been done at all.

Clearly, the specter of WEBCO is a disincentive to some clean coal demonstrations. And a safe harbor provision of some kind would mitigate that problem.

A second safe harbor need is with regard to projects which do not reach their full potential or later fall short in meeting some revised environmental regulation. Utilities simply cannot afford to undertake large expenditures for a specific project if there is the potential for further major expenditures being required in the future to meet Senator Ford's moving target.

Mr. Chairman, the largest threat I believe to the successful completion of the clean coal program may be its interaction with the potential acid rain legislation. Based upon the administration's statement of principles issued last June 12, clean coal may have only a nominal, if any, role in meeting the phase one 1995 reduction target simply because they will not be sufficiently matured in that time frame. Moreover, if widespread use of scrubbers is mandated, there may not be sufficient funds available to simultaneously construct scrubbers and further fund clean coal projects.

And I feel it would be unfortunate, indeed, if utilities were forced to rely on the less efficient technology of the past which, incidentally, creates another environmental problem in terms of wet sludge.

Freedom of choice and an expanded time frame of perhaps two years might accommodate the phase one objectives while keeping clean coal alive.

Finally, let observe that technological development can be accelerated prudently only to a point. Attached to my written remarks is a fast track timetable for commercial development of various

clean coal technologies. It is evident that the three-year extension for certain clean coal repowering technologies proposed under the President's phase two deadline of 2000 does not accommodate clean coal adequately. The extension to perhaps 2005 would be very beneficial.

Furthermore, even to employ clean coal, a decision is going to have to be made in the period 1995–96 on a compliance program because of the time required to install scrubbers. Clean coal demonstration plants may be installed by then, but several years of operational experience and feedback are a necessity as an ingredient in the design of ensuing units.

If past advances in electric generation technology are indicative of clean coal development, which I believe they are, several iterations of the technology will be needed to ensure maturity in terms of suitable operating performance and cost effectiveness. Utilities cannot afford to move too rapidly and too widely because of the financial risk in terms of the potential regulatory challenge to their prudency if the technology does not live up to expectation.

An additional point with respect to any extension beyond the year 2000. It should not be restricted merely to retrofit or repowering technologies. It should be made available where replacement by a new plant is the economic choice over retrofitting or repowering. Surely that would best serve the consumers' interests.

Now, I firmly believe DOE's clean coal program is of great importance and should be actively pursued. It offers this country a series of options in securing our energy future, cleaner environment, and hopefully lower future costs to American consumers. And the latter is of utmost importance to our manufacturing base in meeting the intense global competition.

Thank you.

[The prepared statement of Mr. Disbrow follows:]

WRITTEN TESTIMONY OF

MR. R. E. DISBROW
PRESIDENT AND CHIEF OPERATING OFFICER
AMERICAN ELECTRIC POWER SERVICE CORPORATION

APPEARING AS CHAIRMAN OF THE
CLEAN COAL TECHNOLOGY COALITION

BEFORE THE

SENATE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
U.S. SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

JULY 11, 1989

INTRODUCTION:

Mr. Chairman and Members of the Subcommittee, I am R.E. Disbrow, President and Chief Operating Officer of American Electric Power Service Corporation.

I am testifying today in my capacity as Chairman of the Clean Coal Technology Coalition, an ad hoc group of electric utilities; equipment suppliers; coal companies; architect-engineering and construction firms, eight state governments and universities; the National Coal Association; the Edison Electric Institute and the American Mining Congress. The Coalition, which has a total membership of 86 organizations, was organized in early 1985 for the specific purpose of encouraging the demonstration, deployment and widespread use of clean coal technologies. A listing of our membership is provided as Attachment I to this testimony.

I have been asked to comment upon the DOE's clean coal program and any relevant clean coal-related provisions of S.964, which seeks authorizations for the Department of Energy's civilian energy programs for fiscal years 1990 and 1991. In addition, Mr. Chairman, I take this opportunity to comment also upon the impact which passage of acid rain control legislation might have upon the development of these important technologies, and to suggest to the Subcommittee a number of recommendations which, if adopted, could mitigate the adverse effects such legislation might otherwise have upon continued development of clean coal technologies.

NEED FOR AND BENEFITS OF NEW CLEAN COAL TECHNOLOGIES:

The utility industry is faced with two realities about the technologies currently available to use coal and to control air emissions from the use of coal.

First, conventional pulverized coal units are the only available technology commercially proven for the generation of large amounts of electricity from coal. Because pulverized coal units depend upon economies of scale, they are relatively large units requiring long construction periods and large capital investments. This technology is near the end of its development potential.

Second, the utility industry has available only three conventional options to control SO2 emissions from coal use -- coal cleaning, conventional scrubbers and coal switching.

Each of these methods for controlling coal-derived air pollutants has disadvantages. For example, conventional coal cleaning has only a limited ability to remove sulfur, typically only 10 to 30 percent of the total sulfur in coal. Conventional scrubbers are very costly and can only be retrofitted to an existing unit if sufficient space at the powerplant site is available. In addition, conventional scrubbers use a portion of the electricity produced in the powerplant to operate, thus lowering efficiency. Also, the typical flue gas desulfurization system today produces a wet waste product that causes its own environmental impact. Coal switching could become costly if a significant shift to low sulfur coal occurs and the demand for such coal exceeds the supply. Use of lower sulfur coal in units originally designed for higher sulfur coals can also result in boiler derating which lowers power output, due to coal characteristics which do not meet or are in conflict with the design specifications of a particular boiler. Also, unless designed for low sulfur coal use, the operation of electrostatic precipitators could be adversely affected and such coal use could create problems of particulate compliance. The limitations of these current means to control air pollutants are aggravated by the wide diversity of the nation's utility boiler population in terms of boiler designs, ages, sizes and configurations, as well as the type of coal consumed.

In the face of these realities, the electric utility industry must change its technological base for electricity generation derived from coal. New power generation options are required which can meet increasingly-stringent siting and environmental standards without sacrificing productivity; which can be rapidly constructed in modular fashion while retaining acceptable economies over a wide range of unit sizes to better match uncertain demand growth; and, which are less sensitive to fuel type and quality in a single design. Most important, increased coal utilization must be made compatible with environmental protection. This means that emissions reduction and cost-effective electricity generation must be achieved concurrently and not pitted one against the other. Clean coal technologies are the key to that compatibility. Successful development and use of emerging clean coal technologies can provide a win for ratepayers by moderating increases in electric rates and a win for the environment.

Among the many potential technical and cost advantages of clean coal technologies are the following:

- reduction of sulfur dioxide (SO2) emissions in a more cost effective manner than currently-available technology;

- o simultaneous reduction in some cases of both SO2 and NOx emissions (scrubbers only reduce SO2 emissions);
- o attainment of required environmental control at lower capital and operating and maintenance costs than current technology;
- o utilization of the widest range of coals, from low to high sulfur coals;
- o modularity in some cases, which means units can be sized more closely to match load growth and can take advantage of the economies of shop assembly and pre-fabrications, thereby shortening construction time and cost;
- o cost savings of 10 to 20 percent depending upon plant size for new applications when compared to conventional generation technology;
- o use of existing plants and plant sites in retrofit and repowering applications, thereby avoiding premature plant retirements or replacement with other fuels; and,
- o projected savings of 10 to 30 percent over conventional technologies when retrofitting existing facilities with clean coal retrofit technologies and, if scientific evidence determines the need for emission reductions at older plants then these retrofit technologies would provide attractive economic means by which to achieve reductions.

Furthermore, success in the development of these technologies may preserve American mining jobs in the high sulfur coal fields, will better ensure U.S. industrial competitiveness, and could expand the trade of American coal and technological know-how (without substantial efforts to encourage accelerated development, these technologies will be imported for use and the U.S. will lose its current lead in this field of technology development).

STATUS OF THE DOE'S CLEAN COAL TECHNOLOGY PROGRAM:

As this Subcommittee knows, the Department of Energy is currently conducting a third solicitation for cost-shared clean coal technology demonstrations. After the DOE makes selections at the end of this calendar year, the federal government will have obligated to commit more than $1.5 billion toward the accelerated development of clean coal technologies. Depending upon the actual amount of cost-sharing that industry proposes for round three projects, it is projected that industry will

contribute in excess of $2.5 billion. (If these projections are realized, industry will have committed to its share of the 5-year, $5 billion program after only three rounds of clean coal project selections.) To date, industry has proposed to provide six dollars for every four dollars of public funds, even though the program requires only 50 - 50 cost-sharing. We believe that this level of industry participation is very significant; as a consequence scarce public dollars are being very effectively leveraged into enormous industry commitments. Furthermore, it is quite clear that the current DOE program has accelerated the pace of development of these technologies and this is important from both a national environmental and energy perspective.

The DOE has had considerable difficulty in finalizing negotiations for first round projects which were originally selected in July, 1986. Projects selected in the second round solicitation are not expected to encounter the delays and difficulties that have characterized many of the first round projects. Apparently, this is due in part to more streamlined administration of the program. Also, the industry participants have a better understanding of what will be expected by their government partner.

Given the magnitude of funding already provided to the clean coal program and the accelerated pace at which the DOE has been required to implement the program, the Department is to be commended for the job done. Twenty-nine projects have been selected totalling several billions of dollars in public and private funding. Several projects are well underway and many more are in advanced negotiations. With strong industry support, there is every reason to believe that the program will be very successful.

A principal concern about the current program is the requirement that the federal cost-share be repaid; despite the fact that industry is contributing very significant funding to projects that will benefit the project sponsor and the public as well.

The Clean Coal Technology Coalition has expressed previously our serious reservations about this requirement. Repayment was first imposed by the Office of Management and Budget and the DOE, even though Congress expressed no original intention that such repayment should be required. As a result of this early action, each of the three DOE solicitations has incorporated a repayment provision; albeit, in heeding industry's concerns, each succeeding solicitation has included a less onerous repayment requirement. While the requirement mandated in the on-going third solicitation is less burdensome and more realistic than

the preceding two solicitations, it must be underscored that repayment, which has transformed the program into a government loan, has dampened industry's interest in participation.

While it may be appealing to suggest that repayment will be obtained from "profits" generated by the sale or use of the technology and will be limited to a small percentage of gross sales or a comparable percentage of a license fee, few if any equipment manufacturers may be willing to commit to a long-term loan arrangement. This is especially true since the percentage earmarked by the DOE for repayment often constitutes the entire margin of profit that an equipment manufacturer may realize from the initial sale of the technology. If a demonstration is successful, it is also quite possible that the technology developer (who has taken the risk of development) will be further disadvantaged because a competitor may simply build upon the successful demonstration, and price equipment at less than the DOE participant/vendor who must include in his price the cost of repaying the federal government.

Also, if a vendor or equipment manufacturer refuses to make a commitment toward repayment, though specified in the DOE's requirements, then a utility, serving as the prime contractor to the project, is obligated to identify an alternate repayment method. Thus, the burden for repayment may be transferred back to the utility notwithstanding the fact that the utility may not directly "profit" from the subsequent sale of the technology.

In sum, the requirement that the industry participant repay the federal government should be re-examined. The significant public benefits to be derived if these technologies are successfully demonstrated and deployed would appear to amply justify the government's investment not as a loan but as a grant.

A second matter which is presenting a "chilling" effect upon utility participation in the clean coal program is the possible application of a decision which the Environmental Protection Agency has rendered against a proposed rehabilitation project of a powerplant owned by Wisconsin Electric Power Company (WEPCO). Attached to this testimony as Attachment II is a memorandum which more fully explains this EPA decision and the adverse consequences that its application will have upon the development of clean coal technologies. It might also be noted that EPA's decisions is creating great uncertainty throughout the utility industry about all types of activities involving the up-keep and maintenance of older electric units.

Briefly explained, if the EPA were to apply the WEPCO decision to a clean coal technology demonstration to be conducted at an existing powerplant, that powerplant may be subjected to a

new source review as well as other review requirements like prevention of significant deterioration. Being subjected to such reviews, the existing unit or powerplant could thereafter be required to meet stricter emission requirements than would otherwise be imposed upon the plant had the owner or operator not undertaken the clean coal project. Even if the clean coal technology is only demonstrated for a limited period of time and removed after the demonstration is completed, it is possible that the EPA would thereafter require stricter emissions limits on the existing powerplant.

This EPA decision is serving as a significant impediment to utility participation and, indeed, it may operate to lessen the number of utility-sponsored or utility-hosted clean coal projects in the on-going third solicitation and in any subsequent solicitations. And, in at least one instance regarding an already selected project, the WEPCo decision may preclude the utility host from proceeding with the clean coal project.

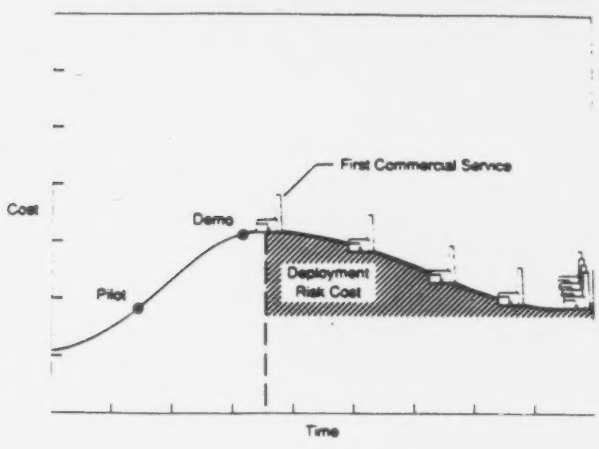
This disincentive to participation in the clean coal program should be removed.

Finally, as this Subcommittee knows, President Bush has requested that an additional $1.2 billion be advance appropriated to conduct Rounds IV and V of the clean coal program. These appropriations will be utilized to complete a commitment which former President Reagan and President Bush have made to the government and Prime Minister of Canada to conduct a $2.5 billion technology development program aimed at new technologies to control emissions from use of coal.

The House Appropriations Committee has recommended that these advance funds be appropriated in fiscal year 1990 pursuant to the President's request, and the Senate Interior Appropriations Subcommittee is scheduled to take action on the President's request in the near future.

The Clean Coal Technology Coalition has endorsed the $2.5 billion cost-share program. We have also recommended, however, that such funding not be limited to one-of-a-kind demonstration projects. Rather, the program should be expanded to insure that replications (deployment) of a demonstrated technology be permitted as well. By clearly authorizing a program in which the same or similar technology is demonstrated in more than one application, industry and the government will best insure that the technology will reach commercial maturity. Each subsequent demonstration will lessen the risks associated with new technology and will diminish costs associated with the technology as industry gains know-how and confidence that the technology will operate at acceptable commercial standards. This is a typical learning experience as depicted in the following chart:

Technology Learning Curve



source: Electric Power Research Institute

Industry needs to know that the DOE has the latitude to support such deployment projects through the current clean coal program. If it is determined that such authority is lacking, then we recommend that this Committee undertake efforts to provide DOE with the specific authority to cost-share such replication or deployment projects.

To insure the accelerated development and subsequent widespread use of these emerging technologies the Clean Coal Technology Coalition has also advocated the adoption of regulatory incentives and the removal of regulatory impediments to the use of new clean coal technologies. Some of these incentives were first incorporated in legislation (S.879) proposed by Senator Robert Byrd, and others, in 1987. In addition, as a part of his commitment to the Prime Minister of Canada, President Reagan called upon his Task Force on Regulatory Relief, chaired by then - Vice President George Bush, to survey and make recommendations for changes to existing regulations in order to stimulate clean coal technology development. That Task Force made recommendations that were accepted in January, 1988, but they have yet to be implemented. Also, the Secretary of Energy has received recommendations from the National Coal Council and the Innovative Control Technology Advisory Panel (ICTAP) regarding government actions that would stimulate clean

coal technology development. These recommendations, as well, should be considered by this Committee in identifying incentives necessary to assure accelerated development and use of these important technologies.

To summarize, the Coalition encourages the Senate Energy and Natural Resources Committee, which has principal jurisdiction over the clean coal program, to consider providing DOE with specific authorities to undertake a clean coal technology deployment program. Such a program should include not only authority to use future appropriations for deployment projects, but also should include additional regulatory incentives like those already recommended by the President's Task Force on Regulatory Relief, the National Coal Council and ICTAP.

IMPACT OF PROPOSED ACID RAIN CONTROL LEGISLATION UPON CLEAN COAL:

The Coalition expects that the Congress may soon turn its attention to proposals seeking to apply stricter controls to emissions from use of coal.

Under ideal circumstances -- given a fully-funded deployment program, implementation of regulatory incentives and without new emission control requirements -- industry would still require much of the 1990's to demonstrate, deploy and bring to commercial readiness clean coal technologies. Attached to this statement as Attachment III is a estimate by the Coalition as to when the various clean coal technologies may be ready for commercial use. Even if a significant program of federal financial incentives for use of clean coal technologies accompanies a control program, it is doubtful that industry would use limited resources to cost-share in the demonstration of new technologies when faced concurrently with requirements for massive emission reductions.

A utility will comply with mandated reduction requirements by switching fuel sources, shutting down powerplants prematurely or retrofitting conventional scrubbers; emerging clean coal technologies will be a very limited option.

Only after successful demonstration and deployment will a particular clean coal technology be considered an option for achieving reductions of atmospheric pollutants; successful demonstration and deployment does not mean that the technology will be immediately and widely incorporated into the nation's electric generation base thereby achieving significant reductions. The utility industry -- each utility -- will proceed very carefully when applying a new technology. This means that for any given utility, a successfully-demonstrated clean coal technology will be applied first to one unit and then another

before being incorporated into an entire system. This market penetration scenario will be replicated many times over throughout the entire utility industry.

Application of clean coal technologies into the entire generation base will be dependent upon many factors and could easily take a decade or more, after achieving commercial maturity. Among those factors are: time to evaluate the technology's performance and to decide to use it on additional units; time to site such projects; to complete permitting and regulatory approvals, including approvals by utility rate regulatory agencies and to place orders and receive equipment from manufacturers of the clean coal technology.

The time required to insure commercial maturity and to achieve introduction and widespread use needs to be considered if the Congress chooses to impose stricter emission requirements. This requirement for sufficient amounts of time, of course, does not mean that clean coal technologies should be exempt from existing local, state or federal requirements intended to protect the environment.

In addition to a sufficient period of time for demonstration and widespread use, it is urged that this Committee address the need to remove regulatory impediments to the use of clean coal technologies. The most important matters in this regard are the uncertainties associated with regulatory review, and the need for mechanisms to better assure cost recovery. Further, some means must be implemented to assure that investments once made are not rendered valueless by subsequent government action. This is especially true with respect to possible change in environmental regulations that could make certain emissions-reduction technologies valueless.

PRESIDENT BUSH'S CLEAN AIR ACT PROPOSAL:

President Bush recently announced his program for amending the Clean Air Act and addressing, in part, emissions from coal-fired powerplants. How a utility will comply with the President's program, if his proposal is finally enacted into law, depends upon the specific, and often unique, circumstances of that utility. Of course, the requirements of a particular control program (for example whether a utility will be given freedom of choice about how to comply or will be forced to use scrubbers), will also dictate the availability of options. In general, if left to the regulated industry to determine compliance strategies, choices for compliance will be dictated largely by the life-cycle costs of the various alternatives, the availability of technologies, as well as coals or other alternative fuels; and simply, the physical constraints at

existing powerplants. For example, the land mass around some powerplants simply cannot accommodate the installation of current-day scrubbers or the disposal of scrubber waste.

With respect to the use of clean coal technologies as a compliance option, important factors to be considered by utility management include: availability and reliability of the technology; performance characteristics with respect to percentage of sulfur and/or NOx removal capability; costs; and proven reliability. Again, to obtain confidence with these emerging technologies, time for development is required.

The President's proposal calls for:

> "A three-year extension of the Phase II deadline (to the year 2003) for plants adopting clean coal repowering technologies, combined with regulatory incentives designed to smooth their transition into the marketplace. This will allow the United States to make good on the major investment the President has called for in clean coal, and will ensure that coal continues to play an important role in America's energy future."
>
> (emphasis added, from: Fact Sheet: President Bush's Clean Air Plan, June 12, 1989, page 4. Office of the Press Secretary).

The three year extension, to 2003, apparently applies only to those plants adopting certain repowering technologies and not to the entire suite of clean coal technologies now under development. In addition, still-to-be-identified regulatory incentives will be made available to some or all of the technologies now under development.

As noted elsewhere in this testimony, it will be difficult to surmount the technical, financial and other risks associated with commercializing certain clean coal technologies in the timeframes outlined in the President's proposal (see: Attachment II). At a minimum, a longer period of time, to the year 2005, would be more realistic if clean coal technologies are to play a significant role in any mandatory reduction program. This additional time would insure that industry develops the confidence in such technologies necessary for widespread commercial use.

With respect to the three year extension referred to in the President's plan, the Coalition makes the following observations:

First, it is assumed that under the President's plan, a utility which commits to using an eligible clean coal technology on a plant will be allowed to operate that plant during the period of the extension.

Second, licensing, permitting, contracting, constructing and placing a currently available scrubber into service could require as much as four to six years. A decision to utilize a clean coal technology will have to be made at the same time a decision would otherwise have been made to use a scrubber. This means that, under the President's proposed program, a decision to use a clean coal technology or a scrubber must be made between 1994 and 1996. The clean coal technologies which the President's plan would make eligible for the extension will not have been adequately demonstrated, at full commercial scale, and available for widespread use by the mid-1990's when a decision regarding the means for compliance must be made.

It should also be noted that the first phase reductions proposed by the President (end of calendar year 1995) will not permit a sufficient amount of time during which clean coal technologies might be used. Again, utilities will have to make decisions about compliance methods to meet the proposed phase one reductions almost immediately (1989 - 1991). Clean coal technologies will not be adequately demonstrated in this timeframe. If additional time were provided to meet the phase one requirements where a clean coal technology is to be used, then it is possible that some of these technologies could be utilized to meet earlier emission reductions.

In view of these concerns about the President's plan this Committee is encouraged to consider the following with respect to clean coal technologies:

1. A provision should be included to make the extension (preferably until 2005) available for applications of clean coal technologies that are intended to replace capacity, as well as those technologies intended to repower existing capacity;

2. The Congress needs to recognize that a technology eligible for the extension may not work and that discovery of such may not occur until too late to switch to another compliance mechanism and still comply by the year 2000. In such cases, a utility that has made a <u>bona fide</u> commitment to the new technology should be permitted the extension in order to reach the required reductions by alternative means, if necessary; and

3. If the Congress is committed to the development and widespread use of all emerging clean coal technologies -- given the significant public expenditure already made and intended to be made on these technologies -- then provisions should be made to insure that all of these technologies, especially those advanced technologies which improve environmental performance and fuel use efficiency and clean coal technologies that achieve current NSPS levels of reduction are eligible for the extension. (Such technologies include; pressurized fluidized bed combustion and atmospheric fluidized bed combustion technologies, integrated gasification combined-cycle technologies, advanced scrubbers or combinations of technologies that achieve NSPS levels.)

With respect to the regulatory incentives mentioned, but not specifically identified in the President's plan, the Coalition recommends that, at a minimum, the following be considered:

1. Include those rate-rated regulatory incentives that were adopted by the President's Task Force on Regulatory Relief, recommended by the National Coal Council, and/or the Innovative Control Technology Advisory Panel. In this regard the adoption of CWIP and accelerated rate amortization for qualifying clean coal technologies would be particularly significant;

2. Grandfather DOE financially-supported clean coal projects and other designated clean coal projects undertaken by a utility without benefit of the DOE cost-share program from further application of the President's emission reduction requirements;

3. Insure that regulatory incentives apply to all plants or units utilizing clean coal technologies and not simply to those which might otherwise qualify for the proposed extension;

4. Consider providing clean coal projects with an extended period of time for meeting the requirements called-for in the first phase of the President's plan, and provide credit against sulfur dioxide reduction requirements in the first phase for any nitrogen oxide improvements obtained; and

5. Recognize that clean coal technologies are like renewable energy technologies -- solar and geothermal -- and would benefit greatly from tax-related

incentives like energy tax credits and rapid tax depreciation schedules which are currently available to renewable energy technologies.

The Clean Coal Technology Coalition would be pleased to work with this Committee and the Congress in further explaining the need for these incentives.

CONCLUSION:

Clean coal technologies promise the greater use of coal in a cost-effective and more environmentally-acceptable manner. The government and industry have embarked upon a unique partnership to develop these technologies. This testimony has outlined those additional actions which the Clean Coal Technology Coalition believes to be necessary if clean coal technologies are to realize their full potential and are to be widely used in the next decade and beyond. Clean coal technologies are important not just for the environmental benefits to be derived but also for the benefits obtainable through relying upon a secure domestic energy resource.

Various utilities are predicting that regions of the country will experience electricity shortages in the immediate future. Others express similar concerns for the coming decade. The nation's commerce is powered by energy, and much of it is sustained by electricity generated from coal. Thus, while the Congress considers environmental legislation and the requirements to be placed upon energy producers in order to achieve national environmental goals, this Committee is urged to carefully consider the impacts such legislation might impose upon the nation's energy goals. In particular, it is recommended that special attention be given to the impacts such legislation might have on the continued development of clean coal technologies.

CLEAN COAL TECHNOLOGY COALITION

MEMBERSHIP

July 7, 1989

A.T. Massey Coal Company, Inc.
Alabama Coal Association
Allison Gas Turbine Division, General Motors Corporation
AMAX Coal Company
American Electric Power Service Corporation
American Mining Congress
Arch Mineral Corporation
Ashland Coal, Inc.
Babcock & Wilcox
Baltimore Gas & Electric Company
Bechtel Power Corporation
Bethlehem Steel Corporation
Carbon Fuels Corporation
Carolina Power & Light Company
Centerior Energy
Central Illinois Public Service Company
Cincinnati Gas & Electric Company
Combustion Engineering, Inc.
Combustion Power
Consolidation Coal Company
Costain Coal Inc.
Cyprus Coal Company
Deutsche Babcock Werke, AG
Duke Power Company
Edison Electric Institute
Florida Power Corporation/Electric Fuels Corporation
Florida Power & Light Company
Fluor Corporation
General Electric Company
General Public Utilities, Inc.
Geneva Steel
Illinois Power Company
Indiana University
Indianapolis Power & Light
Island Creek Corporation
Jersey Central Power & Light Company
M. W. Kellogg Company
Madison Gas and Electric Company
Marietta Coal Co.
Metropolitan Edison Company
MHD Development Corporation
Montana State University
National Coal Association
National Lime Association
NEOS Corporation
Northern Indiana Public Service Co. (NIPSCO)
Ohio Edison

ATTACHMENT I

Ohio Mining and Reclamation Association
Ohio Ontario Clean Fuels, Inc.
Oklahoma Gas & Electric Company
Orange and Rockland Utilities, Inc.
Passamaquoddy Technology
Peabody Holding Company, Inc.
Pennsylvania Electric Company
Pennsylvania Power & Light Company
Pittsburg & Midway Coal Mining Co.
Public Service Company of Colorado
Public Service Company of Indiana
Roberts & Schaefer Company
San Diego Gas & Electric
South East Coal Company
Southern Company Services
Southern Illinois University at Carbondale
Southern Indiana Gas & Electric Company
Stone & Webster Engineering Corporation
Texaco, Inc.
The Commonwealth of Kentucky
The State of Alabama
The State of Colorado
The State of Illinois
The State of Indiana
The State of Ohio
The State of Texas
The State of West Virginia
TransAlta Utilities Corporation
Union Electric Company
United Coal Company
School of Mines and Energy Development, University of Alabama
University of Missouri-Columbia
University of Montana
University of Southern Indiana
University of Wyoming
Virginia Power
Western Research Institute
West Virginia University
Wisconsin Power & Light Company

The WEPCo, Ohio Edison and
Detroit Edison Cases

The October 1988 WEPCo decision of EPA Administrator Thomas and three 1989 decisions of Acting Assistant Administrator Don Clay, involving Wisconsin Electric Power Company (WEPCo), Detroit Edison Company, and Ohio Edison Company (collectively referred to as WEPCo) subject existing units to new source requirements whenever a unit makes a physical change that EPA determines is not "routine."

The utility industry has asked Administrator Reilly to reconsider these unprecedented decisions. The Bush Administration should support reconsideration and should resist attempts by EPA staff to lock the administration into WEPCo through proposed legislative amendments that assume administrative reconsideration is not possible.

As explained in the attached Briefing Paper, unless reconsidered, WEPCo will:

- Prevent utilities from switching from oil to natural gas without first receiving a new source "PSD" permit. This will discourage conversions from oil to much lower polluting natural gas.

- Prevent utilities from installing "clean coal" technologies, or from installing conventional control technologies, without first receiving a PSD permit. This will discourage participation in the "clean coal" program and discourage installation of cost effective control technology in Phase I, thereby increasing coal market impacts in the near term and preventing the introduction of "clean coal" technology in the long term.

- Undermine any "cost effective" emission reduction strategy for Phase 1 and 2 by subjecting older, smaller (e.g., units less than 100 megawatts, like the WEPCo units) to mandatory scrubbing (even though fuel switching would be a far less costly way of achieving reductions) whenever such units undertake "non-routine" repair and replacement programs needed to return those units to past operating levels.

- Produce electric reliability problems by forcing utilities to defer renovation projects that are needed to improve or maintain reliability, efficiency, or availability of units.

ATTACHMENT II

June 20, 1989

BRIEFING PAPER
ON EPA RECONSIDERATION OF
THE WEPCO, DETROIT EDISON,
AND OHIO EDISON DECISIONS

In October 1988, Administrator Thomas affirmed a determination of then Acting Assistant Administrator Don Clay finding that new source performance standards (NSPS) (i.e., SO2 scrubbers) and prevention of significant deterioration (PSD) new source permitting requirements would apply if a maintenance, repair, and replacement project (called a "life extension" project) planned at a five unit coal-fired electric generating plant owned by Wisconsin Electric Power Company (WEPCo) went forward. WEPCo was seeking to replace equipment that posed safety concerns at four of the units and required shutdown of one of those units. In addition, replacement of defective equipment was required at two units to allow those units to operate again at design capacity. The remainder of the repairs and replacements in the project were needed to improve efficiency and reliability without having any impact on emission rates.

On February 15, 1989, Acting Assistant Administrator Clay resolved additional issues posed by WEPCo. Among other things, he determined that WEPCo could not avoid NSPS by switching to a lower sulfur coal, but rather would need to install scrubbers or similar controls. He also found that PSD review would be required even though the units were not increasing their emission rate.

In the Detroit Edison case, EPA Region V determined that a project to allow natural gas-firing at an oil-fired plant could not be undertaken without a PSD permit. In a May 5 letter, Don Clay observed that the project would substantially reduce emissions, but he nevertheless tentatively concluded that Region V's PSD determination appears to be "correct."

In the Ohio Edison case, EPA determined that removing a clean coal technology demonstration project after the demonstration concluded would trigger PSD and NSPS requirements. Although EPA Acting Assistant Administrator Clay promised "no action" in terms of EPA civil enforcement, "clean coal" participants would still

potentially face criminal penalties for "knowing" violations of the Clean Air Act and would be subject to citizen suits under the Act. In other words, EPA has made clear that removing a clean coal demonstration project is unlawful (in EPA's view) and has informed those undertaking these demonstration projects that, at most, EPA will not initiate a civil action. Citizens and a local U.S. Attorney can do what they want.

The Utility Air Regulatory Group[1/] has requested that Administrator Reilly reconsider these decisions. Detroit Edison is separately seeking review of the Region V decision concerning its natural gas project.

EPA's New Interpretation of
the NSPS and PSD Requirements

New Source Performance Standards (NSPS) require new sources to meet a 70-90% scrubbing requirement and other stringent emission limitations. The Prevention of Significant Deterioration (PSD) permit program imposes numerous monitoring and modeling requirements on new sources, as well as technology-based emission limits that are potentially more stringent than NSPS. Existing sources are subject to NSPS and PSD if they are "modified," that is, if they undergo physical or operational changes that increase emissions.

The WEPCo, Detroit Edison, and Ohio Edison decisions substantially expand the previous understanding of what is a "modified" source for NSPS purposes. Under these decisions, if emissions immediately before a "non-routine" (as determined by EPA staff) change are less than emissions after the change, NSPS is triggered. This is the case notwithstanding the fact that the emissions immediately before the change are not representative of normal source operations.

1/ The Utility Air Regulatory Group (UARG) is a voluntary, nonprofit, unincorporated, ad hoc group of 65 electric utilities, the Edison Electric Institute, the National Rural Electric Cooperative Association, and the American Public Power Association. UARG's purpose is to participate on behalf of its members collectively in federal air pollution control regulatory activities and in related litigation. Since 1977, UARG has been involved in all major Environmental Protection Agency Clean Air Act rulemaking and in numerous judicial proceedings related to these rulemakings.

EPA similarly expanded the "modification" requirements that apply to the PSD program. Under these decisions, if EPA finds a change to be "non-routine," EPA will always conclude that the change causes an emissions increase since EPA compares actual annual emissions before the change with the emissions projected from operating 100 percent of the time, at 100 percent capacity, for 365 days. This approach, which allows projects an emission increase, conflicts with the plain language of EPA's rules.

EPA's decisions acknowledge that "routine" repairs and replacements are not subject to the NSPS and PSD modification rules. However, the Agency has arbitrarily redefined what repair and replacement activities are "routine," such that "routine" activities include only those that (1) are frequently done at that plant, (2) involve no major equipment, (3) are inexpensive, and (4) do not extend the life of a plant. This new interpretation is vastly different from past implementation of the "routine" rule, which included any repair and replacement activity that is normal business practice. It gives EPA staff virtually unlimited discretion to find that any major repair or replacement project is "non-routine."

Direct Impacts of the WEPCo, Detroit Edison, and Ohio Edison Decisions

Under these decisions:

1. A unit that discovers safety problems due to an unanticipated defect in equipment and shuts down pending repairs cannot resume operations without meeting stringent new source standards and receiving a new source prevention of significant deterioration ("PSD") permit. This occurs whenever EPA determines the repair or replacement is not "routine." WEPCo, Port Washington Unit 5, October 14 letter.

2. A unit, under the WEPCo decision, cannot repair or replace deteriorated or defective equipment needed to return to past maximum operating levels, unless the repairs or replacements are "routine." WEPCo.

3. A unit cannot avoid an emissions increase that would trigger new source

standards by switching to a lower sulfur coal or oil, or to natural gas. It must install control technology (e.g., scrubbers). WEPCo, February 15 letter.

4. A utility experiencing increased forced outages at its units due to equipment problems cannot undertake repairs needed to avoid serious electric reliability problems without applying for and receiving a PSD permit, even though these repairs will only improve reliability and efficiency and will not increase the emission rate of the units. This occurs whenever EPA determines these "emissions neutral" or even "emissions beneficial" repairs or replacements are not "routine." WEPCo, Detroit Edison.

5. A unit that was not able to burn a lower polluting fuel (e.g., natural gas) in the past cannot be converted to burn that fuel without first applying for and receiving a PSD permit. Detroit Edison.

6. A unit that has undertaken a "clean coal" demonstration project must meet new source standards and obtain a PSD permit if it wishes to remove the experimental technology at the end of the demonstration period. EPA may issue a "no action" assurance to such a project. Ohio Edison. A "no action" assurance is a promise by the EPA signatory (in the case of Ohio Edison, an Acting Assistant Administrator) that EPA will not bring a civil enforcement action. This does not insulate the company from a "citizen suit" under the Clean Air Act. Also, as the attachment to the EPA Ohio Edison letter makes clear, a U.S. Attorney can still bring a criminal prosecution.

Broader Consequences of the WEPCo, Detroit Edison, and Ohio Edison Decisions

1. WEPCo will wholly undermine any "acid rain" legislation designed to allow reductions in the most cost-effective way. For example, it subjects many older, smaller units to scrubbers when these units are the logical candidates for fuel switching.

2. WEPCo is presently causing utilities to defer needed major maintenance, repair and replacement projects required for electric system reliability. The

consequence of such deferrals is that utilities must risk interruption of service in the very near future or costly expenditures on short-term solutions (e.g., unplanned installation of combustion turbines). Given the time required to obtain a PSD permit to undertake a repair program at an existing unit or to install a new combustion turbine, a substantial deterioration in electric reliability in the near future — with serious health and environmental consquences — is likely unless WEPCo is revisited.

3. For other industries, WEPCo says: you may not undertake major repairs or replacements that restore a plant to its past levels of production unless someone in an EPA region or EPA headquarters finds that the project is "routine." Given EPA's restrictive interpretation of "routine," the WEPCo decision means that such projects cannot be undertaken without assuming substantial risks or seeking a determination from EPA that could take 6 to 12 months.

4. Even more troublesome is the WEPCo determination that major repairs and replacements that improve "reliability" and "efficiency" but do not increase (and may even reduce) emission rates can require a PSD permit unless EPA determines that the project is "routine." This aspect of the WEPCo decision is hostile to improving the productivity of our basic industries.

5. Utilities and others that want to reduce emissions by converting to natural gas are barred from doing so without a PSD permit unless they were capable of burning gas in 1975. This will cause companies to abandon such conversions in many cases and delay them (due to PSD permitting requirements) whenever a company decides to proceed.

6. If the WEPCo rationale is not qualified, utilities face substantial risks undertaking a "clean coal" demonstration project. If new source requirements apply upon removal of the experimental controls, a unit will have to be shut down or face very costly retrofit controls. The price may be too great for many companies, thereby discouraging participation in the program.

Adminsitrative Solution to the WEPCo, Detroit Edison, and Ohio Edison Cases

In the WEPCo, Detroit Edison, and Ohio Edison decisions, EPA interpreted its new source performance standards (NSPS) and prevention of significant deterioration (PSD) requirements in an unprecedented manner. While the rules governing these EPA programs are complex, the EPA determinations in these cases could be easily overcome with the following interpretations:

1. For NSPS purposes, EPA can, and should, recognize that, in determining an emissions increase, representative operations of the unit should be used in comparing past emissions to future emissions after a change. Nothing on the face of EPA's regulations or their regulatory history precludes such a declaration by the new EPA Administrator. Such a "clarification" would mean that "clean coal" technologies could be removed at the end of the demonstration period without triggering NSPS. It would also allow utilities and other industries to make necessary repairs to return plants to past maximum production levels.

2. For PSD purposes, EPA can, and should, recognize that any emission increase predicted to occur as a result of an increase in hours of operation or production rate up to original design capacity (unless limited by a federally enforceable restriction on production or hours) is an exempt emission increase, as § 52.21(b)(2)(iii)(f) of EPA's rules explicitly and unambigiously provides. This reconsideration of the WEPCo, Detroit Edison, and Ohio Edison decisions would allow "clean coal" projects to proceed without having to receive a PSD permit. It would also allow industry to convert to lower-emitting natural gas without a PSD permit.

ESTIMATED COMMERCIAL AVAILABILITY OF CLEAN COAL TECHNOLOGIES

Government policy-makers are concerned about *assuring the commercialization of clean coal technologies* and *not losing or wasting the multi-billion dollar investment now being made in the development of these technologies.* These concerns are raised in the context of the debate about the need to impose more stringent controls on emissions. The often asked question is: "How much time is required to commercialize clean coal technologies?" The answer is twofold:

First, sufficient time to demonstrate, deploy and integrate these technologies into the electric generation system. More specifically:

- a successful demonstration/deployment program could result in *a variety of clean coal technologies available for commercial order by the mid- to late-1990's.* An emissions control program that mandates reductions in the early 1990's would prevent utilities from directing resources to clean coal, resulting in a postponement or abandonment of new technology development; and

- once clean coal technologies are available for commercial order, *an additional period of time — as much as 5 to 10 years — will be required for utilities to develop confidence in the technologies and place them into widespread commercial use.** A control program that mandates significant reductions during this same time period and that does not provide flexibility for compliance, will force utilities to abandon these technologies in favor of currently available (and proven) control mechanisms.

Second, assuming a sufficient amount of time is provided before any mandated emission reductions are required, clean coal technologies will require full funding of the on-going $2.5 billion clean coal program; inclusion of support for multiple applications of the same or similar technology (i.e. deployment) as a part of the on-going program and modification of existing regulations governing electric rates and flexibility in environmental regulations currently applicable to new technology development.

* *User confidence* can only be established by the installation or utilization of the commercially available technology on a succession of existing or planned units. Utilities not directly involved in the initial technology demonstration will subsequently undertake installation or use of the technology in much the same unit by unit fashion. *The process of initially incorporating these technologies into the systems of various utilities will take time -- time to evaluate the technology's performance and to decide to use it on additional units; time to site such projects; to complete permitting and regulatory approvals, including approvals by utility rate regulatory agencies, and to place orders and receive equipment from manufacturers of the clean coal technology.* As user confidence increases, a greater number of each successfully demonstrated technology will be incorporated into various utility systems until the technology penetrates the available market and is generally accepted industry-wide as a readily available and proven option.

ATTACHMENT III

Range of Estimated Commercial Availability Dates of Clean Coal Technologies

(assume implementation of a clean coal deployment program[1])

Technology Class	Available for Commercial Order[2] (Range of Estimates)	Potential Widespread Commercial Use to Achieve Reductions of Air Pollutants[3]
Advanced Physical Coal Cleaning	1994-1996	2000-2005
Chemical Coal Cleaning	1998-2000	2010-2015
Low Rank Coal Drying	1993-1995	1998-2000
Coal Upgrading	1998-2000	2005-2010
Advanced and Regenerable FGD	1995-1998	2005-2010
Furnace Sorbent Injection	1993-1995	2000-2005
Duct Sorbent Injection	1994-1996	2000-2005
NOx Control During Combustion	1994-1996	2000-2005
NOx Control Post Combustion	1996-1998	2005-2010
Integrated Gasification Combined Cycle	1994-1996[4]	2000-2005
Utility-Scale Atmospheric Fluidized Bed	1994-1996[4]	2000-2005
Pressurized Fluidized Bed	1998-2000	2005-2010

[1] Widespread commercial use of new technology requires that significant economic incentives are present that differentiate that new technology from other pre-existing methods for achieving the same goals. Such incentives must be readily apparent as a result of successful demonstration of the technology in a variety of situations so that there are no technology risks or abnormal project risks for the new user. Utilities must not risk decisions by regulatory bodies acting retrospectively that have a significant probability of being judged imprudent. As a result of these factors widespread utility adoption of new technology is likely to take a long time.

[2] Assumes that the ongoing clean coal technology demonstration program continues; that a deployment program providing for several subsequent commercial-scale demonstrations of the same or similar technology will be fully implemented (number of deployment projects will vary by technology); that neither the demonstration nor deployment projects will fail; and, that deployment projects of the same generic technology will be initiated roughly in parallel and not in sequence to accelerate further the development schedule, (though the sequential approach would save dollars and permit maximum learning value from the prior projects). A successful deployment program is intended to provide sufficient operating experience with a given technology to establish technical feasibility, economic competitiveness with other commercially-available options, and qualified suppliers capable of guaranteeing the technology's performance.

[3] Assumes that industry will not be precluded from using the technology once it has been successfully demonstrated and deployed. To make a significant contribution to the reduction of atmospheric pollutants, the clean coal technologies must penetrate the market. Depending upon the degree of difficulty, size and complexity of each clean coal project or application, each commercial clean coal project will require 2 to 3 years from start date to placed-in-service date for simple engineering modifications and 5 to 7 years for projects requiring major equipment installation. Initially, to minimize risk, a utility will apply a retrofit or repowering technology to one or two units and not to the entire system. Once that utility gains experience and confidence in the technology it will likely be applied to other units on that utility's system. Each utility is likely to proceed in this same manner depending upon its individual, and unique, circumstances. Further, utilities will not all proceed to use such technologies at the same time. Therefore, significant market penetration which, in turn, will likely yield a significant contribution to the reduction of air pollutants, will take time. A decade beyond the date of commercial readiness is not an unreasonable estimate. Forcing use of the technologies through requirements for early reductions will only lead to abandonment of the newer technologies in favor of currently available technology, for example, wet-limestone scrubbers.

[4] Several equipment suppliers and manufacturers are currently prepared to offer, with performance guarantees, gasification units or atmospheric fluidized bed boiler units. However, gasification units have yet to be demonstrated in large-scale, economically integrated multiple equipment trains. And, atmospheric fluidized bed units, while large enough for some utility applications, are generally considered too small for widespread utility use. The estimated availability dates cited in the chart assume (i) that atmospheric fluidized bed boilers will have been demonstrated and deployed, by those dates, at a size large enough (greater than 400 megawatts) to be suitable for widespread utility-scale use or (ii) that integrated gasification combined cycle powerplants will have been demonstrated and deployed at a variety of locations using various ranks of coal and gasifiers and verifying the economic and technological integration of multiple equipment trains up to and exceeding 400 MW in size.

Senator FORD. Thank you, Mr. Disbrow.
Dr. Squires.

STATEMENT OF DR. THOMAS G. SQUIRES, PAST CHAIRMAN, FUEL CHEMISTRY DIVISION, AMERICAN CHEMICAL SOCIETY

Dr. SQUIRES. Mr. Chairman and members of the subcommittee, my name is Thomas G. Squires. I am Past Chairman of the Division of Fuel Chemistry of the American Chemical Society and Executive Director of Associated Western Universities, a science education consortium. The division is comprised over 1,000 chemists and engineers whose primary interest is in alternative fossil fuel research and development. The ACS board of directors has authorized my presentation of this statement of the society's views regarding Federal support for coal research and development.

We believe that fundamental coal research activities should be pursued more vigorously than ever to support the implementation of clean coal technologies under consideration and the development of coal conversion processes necessary for the thorough utilization of our most abundant domestic energy resource. The benefits of developing a fundamental understanding of coal behavior can be illustrated by examining the current state of coal combustion technology.

Combustion is clearly the most advanced technology for coal utilization. Yet, the ability to predict coal combustion behavior is based on empirical correlations. These correlations were developed through decades of experience inventing and operating combustion devices of slowly increasing scale. Even with this vast experience, approximately $10 million must be invested in testing to establish sufficient confidence in the use of a new design or in the combustion of a new coal in a standard design.

Developing an empirical data base for each technology is much too costly and slow. Furthermore, such an empirical approach is not practical for developing processes designed to meet the new constraints of acid rain and global warming, such as the processes being demonstrated in the clean coal technology program.

The solution is to evaluate and develop coal utilization technologies based on a fundamental, as well as an empirical, understanding of coal conversion behavior and on general predictive capability. Such fundamental understanding and predictive capability is a practical goal and should be supported.

However, support for coal research is being reduced. An examination of the federally supported coal research programs in fossil energy shows that in the last five years the overall support, when adjusted for inflation, has dropped by 22 percent. These lower levels of Federal support are forcing rejection of relevant and excellent proposals with the resulting exodus of scientists and engineers from fossil energy R&D.

Recently a telephone survey of 22 organizations engaged in government and industry coal research was conducted by the Geochemistry Division of ACS. This survey group consisted of seven universities, ten industries, three government laboratories and two nonprofit laboratories. The survey revealed that the number of coal

researchers employed in 1988 is less than half of the number five years ago.

Overall, the United States faces a significant future shortfall in scientists and engineers. The human resource situation is especially critical in fossil energy where there are insufficient funds to support graduate research and training. Once students acquire degrees, they are often attracted to other fields due to inadequate research support in the fossil energy area. Therefore, the field is not only losing established researchers, it is not gaining any new, young scientists.

The ACS strongly believes that one appropriate method for enhancing scientific education is through strong Federal funding support for fundamental fossil science and engineering research. In order to meet these important national needs, the American Chemical Society recommends funding for advanced coal research programs be expanded from $41.5 million in fiscal year 1989 to $80 million in fiscal year 1990 to provide support for fundamental research, education and graduate study.

The society also urges that research in support of the clean coal technology program be funded by a 10 percent setaside from the fiscal year 1990 budget for that program.

Strong support for clean coal technology should also continue and a comparable coal technology development program should be established to address global warming.

It is necessary for us to make choices today which will affect our energy futures of tomorrow. The American Chemical Society hopes that your subcommittee will consider the positive impact on energy independence and the scientific work force development implicit in these recommendations and move your budget recommendations to make them possible. The American Chemical Society hopes that you will consider its recommendations and thanks you for the opportunity to express its views.

This concludes my testimony.

[The prepared statement of Dr. Squires follows:]

S T A T E M E N T

of the

American Chemical Society

STATEMENT

of

DR. THOMAS G. SQUIRES

on behalf of the

AMERICAN CHEMICAL SOCIETY

to the

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

on the

DEPARTMENT OF ENERGY FOSSIL R&D FY 1990 AUTHORIZATION

TUESDAY, JULY 11, 1989

American Chemical Society • 1155 Sixteenth St., N.W. • Washington, D.C. 20036 • (202) 872-4479

Mr. Chairman and Members of the Subcommittee:

My name is Thomas G. Squires. I am the past-Chairman of the Fuel Chemistry Division of the American Chemical Society. The Division is comprised of over 1,000 chemists and engineers whose primary interest is alternative fossil fuel research and development. I am pleased to appear before you today with the authorization of the Society's Board of Directors to present the ACS views on federal support for coal research and development.

The American Chemical Society believes that the following four issues need to be addressed during the FY 1990 budget process:

- Increased coal utilization can help reduce the balance of payments deficit and provide for a secure energy supply;
- Important environmental problems--acid rain and the greenhouse effect--connected with fossil fuel utilization must be resolved;
- A fundamental research foundation is necessary to examine these environmental problems; and
- A critical number of active and teaching scientists must be maintained in fossil energy to develop the necessary research foundation.

Many aspects of coal utilization are important to the national interest. Increasing domestic utilization can reduce the use of oil and, thereby, help reduce the balance of payments deficit while increasing the security of the Nation's energy supply. The deficit also can be reduced by the export of coal as well as of new, efficient, reliable, and clean coal conversion technologies. However, the burning of coal has potential negative effects since it contributes to the acid rain problem and to global warming through the greenhouse effect. It is desirable to optimize the positive effects of increased coal utilization while eliminating or at least minimizing the causes of the negative effects.

Recognizing the need to address environmental concerns, the Congress established the Clean Coal Technology Program to demonstrate coal conversion technologies capable of reducing coal's contribution to acid rain. Recently introduced legislation addresses the greenhouse effect.

Unfortunately, a corresponding expansion of research funding to meet these new challenges has not occurred. Focused coal research activities should be pursued more vigorously than ever to support the development of the many new coal conversion technologies under consideration. The benefits of pursuing focused coal research can be illustrated by examining the U.S. history in coal technology. The most advanced technology for coal utilization exists for combustion, yet the ability to predict coal combustion behavior is based on empirical correlations developed through decades of experience inventing and operating combustion devices of slowly increasing scale. Even with this vast experience, approximately $10 million in testing and use must occur before sufficient confidence is reached for the combustion of a different coal type in a standard design or in the use of a new design.

This empirical experience is not necessarily applicable to processes designed to meet the new constraints of acid rain and global warming. Also, developing an empirical data base for each technology is much too costly and slow. Coal utilization technologies can best be evaluated and developed based on a fundamental, as well as an empirical, understanding of coal conversion behavior and on general predictive capability. Given the many advances made during the past ten years, such fundamental understanding and predictive capability is a practical goal if more relevant coal research is supported.

However, support for coal research is being reduced. A recent telephone survey of twenty-two organizations engaged in government and industry coal research (seven universities, ten industries, three government laboratories, and two nonprofit laboratories) was conducted by the ACS Division of Fuel Chemistry. The survey revealed that the number of employed researchers in 1988 has dropped to less than half of the number five years ago. An examination of the federally supported coal research programs in Fossil Energy shows that in the last five years the overall support, when adjusted for inflation, has dropped by 22 percent and that the funding to nongovernment laboratories has dropped by 33 percent. These lower levels of federal support are forcing rejection of relevant and excellent proposals, with a resulting exodus of scientists and engineers from fossil energy R&D activities.

Overall, the United States faces a significant future shortfall of scientists and engineers. The human resource situation is especially critical in the fossil energy area where there are insufficient funds to support graduate research and training. Once students acquire degrees, they are often attracted to other fields due to inadequate research support in the fossil energy area. Therefore, the field is both losing established researchers and not gaining any new young scientists. In a report on Science and Engineering Education (July 1988) of the Energy Research Advisory Board, this potential shortfall was recognized. The report recommends that:

> "The Department of Energy should ... Allocate funds to ensure that scarce resources are appropriately distributed 1) to emphasize DOE's primary educational mission in support of graduate students and postdoctoral fellows, and 2) to augment the support of precollege programs that enhance the quality and enlarge the pool of potential science and engineering students."

The ACS strongly believes that one appropriate method for enhancing scientific education is by strong federal funding support for fundamental fossil science and engineering research.

In order to meet these important national needs, the American Chemical Society offers the following recommendations:

- Support research programs that will provide a sound foundation for understanding coal structure and chemical and physical behavior in order to permit development of novel, more efficient processes and of reliable predictive modeling of coal conversion in support of the important coal conversion technology development programs.

- Expand the level of funding for Advanced Coal Research Programs (See Appendix I) from $41.5 million in FY 1989 to $80.0 million in FY 1990 to provide support for fundamental research in the areas indicated.

  (In a January 30, 1989, letter to your Subcommittee (Appendix II), the ACS urged that research in support of the Clean Coal Technology Program be funded by a ten percent set-aside from the FY 1990 budget for that Program.)

- Continue strong support for the Clean Coal Technology Program which addresses acid rain concerns.

- Establish a comparable coal technology development program that addresses global warming focused on the elimination and/or utilization of the secondary greenhouse gases (nitrous oxide, ozone, methane, etc.), the maximization of the useful energy per pound of carbon dioxide produced, and the optimization of mitigation strategies.

The American Chemical Society appreciates this opportunity to express its views. The Society hopes that your Subcommittee will consider these recommendations for implementation during your deliberations on the Fossil Energy R&D budget for FY 1990.

Appendices

APPENDIX I

Federal Support for
Advanced Coal Research Programs (a)
(Dollars in Thousands)

	Coal Liquefaction Advanced Research	Surface Coal Gasification Advanced Research	Control Technology & Coal Preparation Advanced Research	Combustion Systems Advanced Research	Fuel Cells Advanced Research	Advanced Research & Technology Development	TOTAL
1981						$58,383	$58,383
1982						51,936	51,936
1983						31,650	31,650
1984						38,996	38,996
1985	$5,511	$3,364				30,804	39,679
1986(b)	5,157	3,379				33,849	42,385
1987	4,470	2,806	$1,139	$3,248	$1,350	26,630	39,643
1988	6,132	2,698	2,042	3,351	1,547	24,937	40,707
1989	6,902	2,679	1,774	2,972	1,597	25,564	41,488
1990(c)	3,099	652	1,871	1,141	977	25,543	33,283

a. Until 1986, Coal Liquefaction Advanced Research and Surface Coal Gasification Advanced Research were funded under Advanced Research and Technology Development as the Processes subprogram. Part of the Direct Utilization subprogram under AR&TD was transferred to Advanced Research within Control Technology and Coal Preparation, Combustion Systems, and Fuel Cells to comply with FY 1988 Congressional direction.

b. Enacted budget, after 4.3% reduction due to Gramm-Rudman-Hollings deficit reduction legislation.

c. Administration's Budget Request.

Source: Budget Justification Books for the Department of Energy.

APPENDIX II

American Chemical Society

OFFICE OF THE
PRESIDENT

Clayton F. Callis
President-Elect, 1988
President, 1989
Immediate Past President, 1990

1155 SIXTEENTH STREET, N.W.
WASHINGTON, D.C. 20036
Phone (202) 872-4600

January 30, 1989

The Honorable Wendell H. Ford
Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

The American Chemical Society, with many of its 137,000 members employed in energy and related industries, appreciates the continued support that you and your Subcommittee have given to Fossil Energy R&D programs. The Society would like to take this opportunity to bring to your attention its concerns regarding a related program.

The Clean Coal Technology Program represents a vital initiative by the U.S. government and industry. While the projects that are being funded are based on a significant technological foundation, they would benefit substantially by supporting research that would ensure their optimization, improvement, scale-up, and reliable operation. Furthermore, additional research is needed to seed the next generation of clean coal technologies.

In testimony last year before Congress, the American Chemical Society recommended that ten percent of the Clean Coal Technology budget in FY 1989 be used to support research relevant to that program, and that this level of funding be sustained in subsequent fiscal years. The Society urges that ten percent be set aside from the FY 1990 budget for the Clean Coal Technology Program and designated for Clean Coal Technology Supporting Research.

The Society's examination of the technologies employed in projects submitted in the first and second rounds of the program suggests that there are a number of technical areas which would benefit from such supporting research. These areas include:

- The chemistry and physics of coal as it relates to feedstock preparation;
- The predictive capability of coal conversion processes including combustion and gasification, as well as mild gasification;
- The characterization of coal mineral matter and its behavior during coal conversion processes;
- Novel methods of flue gas cleanup including hot gas cleanup;

- The chemistry of formation and control of oxides of nitrogen and sulfur;
- Carbon dioxide control and its role in the greenhouse effect;
- The development of novel catalysis systems for economical operations in coal conversion and utilization;
- The chemistry of co-processing; and
- Understanding the chemistry of interaction between ash/slag and refractory material with the goal of reducing plant downtime.

While many of these topics are addressed under present DOE sponsored programs, the focus and levels of support of these activities are not sufficient to provide optimum and timely assistance to the Clean Coal Technology Program. The American Chemical Society believes that establishing such a research component would improve the productivity and probability of success of the Clean Coal Technology Program.

To maximize the effectiveness of this research, the ACS recommends that half of the Clean Coal Technology Supporting Research funds be used for research on new clean coal concepts and that the other half be used for research relevant to the funded Clean Coal Technology Demonstration projects. The Society also believes that the research should be performed at laboratories not involved with demonstration projects in order to ensure a long-range focus.

All these research funds should be awarded on the basis of peer review of submitted proposals. The Society recommends that companies carrying out the demonstration projects should participate in the selection of the relevant research proposals to be funded in order to ensure applicability.

The ACS Fuel Chemistry Division has offered to assist in this process by publicizing the topics of interest or suggesting reviewers for the proposals.

The American Chemical Society hopes that you will consider these recommendations for implementation as you take up the Fossil Energy R&D budget request for FY 1990 and offers its continued assistance in this area.

Sincerely yours,

Clayton F. Callis

Clayton F. Callis

cc: Other Members, Senate Subcommittee on Energy Research and Development

Senator FORD. Thank you very much, Dr. Squires.
Mr. Webb.

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE

Mr. WEBB. Thank you, Mr. Chairman and members of the committee.

Before I summarize my statement, I would like to echo the statements that you and Senator Domenici made earlier about the Gas Research Institute at least in its dealing over the last eight years with the fossil energy program. It has certainly found a more receptive Secretary in Allen Wampler than previously. While it is primarily a coal program, at least when we went to him with what we thought was a sound research concept, we got a fair hearing. And I think that is all anyone can ask. So, I would just like to say on our behalf, we certainly hate to see him leave also, Mr. Chairman.

Senator FORD. Thank you, Mr. Webb. I am sure the Secretary will enjoy those remarks. He may not be able to eat or live on them, but he will enjoy them. [Laughter.]

Mr. WEBB. I appreciate the opportunity to appear before you today to present GRI's fiscal year 1990 budget recommendations for gas-related research in DOE's fossil energy program. In developing these recommendations, GRI gave priority to the top three issues: one, the need to develop our extensive domestic gas resources; two, the need to reduce U.S. dependence on imported oil; and three, the critical role gas can play in helping to solve some of our environmental problems. Therefore, GRI and the gas industry are recommending $73.4 million for gas research in the DOE fossil energy program to continue programs that Congress has previously approved.

Central to this recommendation is the fact that GRI is planning to commit $69.1 million to research in these same program areas. In the past Congress has recognized the need for this research and has appropriated approximately $65 million each year for these DOE programs.

DOE's budget is a major factor influencing the GRI program since GRI co-funds annually about $30 million of its research projects with DOE. Therefore, even though GRI is not a government contractor, the congressional action on the proposed DOE budget has a direct impact on GRI's program.

I think it would be useful to consider some recent DOE energy policy statements versus budget reality. The DOE Energy Security Study released in March 1988 concluded that U.S. oil imports would probably increase substantially by 1995 ranging from 8 to 10 million barrels per day. The study also concluded that abundant domestic natural gas is a fuel that is most readily substitutable for oil.

To follow up that study, in February 1988, DOE announced a major new study to do a comprehensive assessment of the U.S. natural gas resource potential. In announcing the study, Secretary Herrington stated: "Our growing dependence on imported oil is an Achilles heel." He further stated: "This is an opportune time to re-

assess the role natural gas can play in displacing imported oil." In May 1988, DOE completed this detailed assessment. The results show that over 1,000 trillion cubic feet of gas is technically recoverable by using advanced technology. Included in this recoverable base is 259 trillion cubic feet in unconventional resources.

However, when we look at the DOE 1990 budget request, it seems to be totally inconsistent with these policy conclusions. The total budget request for gas-related research in the entire DOE fossil energy program is only $25.7 million, a reduction of 62 percent from the $62 million Congress appropriated last fall. In unconventional gas R&D, the request is only $4.1 million, less than 1 percent of the proposed fossil energy budget. The budget as submitted does not support the policy or conclusions of recent DOE studies.

The U.S. energy research policy that essentially ignores gas-related R&D and the role gas can play in meeting future energy demands hastens the day oil imports exceed 50 percent of consumption.

One obvious option to reduce oil imports is to substitute natural gas where feasible. An expanded joint effort between the gas industry and DOE is needed if this is ever to become a reality.

Before I make a few specific R&D program recommendations, I would like to briefly summarize three policy issues we think are important.

One, GRI supports the gas industry's proposal to create the post of assistant secretary for natural gas and oil in DOE. Oil and gas provide over 65 percent of current U.S. energy needs, projected to provide over 50 percent of U.S. energy needs even in the year 2010. Yet, the DOE fossil energy budget devotes less than 6 percent of its funding to R&D in these two resource areas. We need a better balance between U.S. energy R&D and the way we use energy in this country.

Two, GRI would recommend that we continue and expand cooperative R&D ventures. We believe the current cooperative R&D venture with GRI and DOE in secondary gas recovery is an example of the type of joint program required to effectively and quickly transfer technology to the private sector.

Through industry's willingness to invest its own resources, at least 50 percent of the project funding, the research is managed and directed in a responsible way. In short, a joint R&D venture offers a relative low-cost route to innovative technology through pooling of government and industry resources.

The third policy issue is we would ask a recognition of the role that gas can play in clean coal technologies. Federal policy has long overlooked the significant role natural gas can play in helping the Nation use coal in an environmentally acceptable manner. In fact, for many retrofit applications, especially older and smaller power plants, gas used in combination with coal systems is probably the most cost effective solution.

Gas can be used with coal in a single combustor to reduce both SO_2 an NO_x. The use of gas as part of an overall approach to controlling flue gas emissions should be one element of the national energy policy because not only is it cost effective, in many cases it gives the local utility the flexibility to continue to use local, high sulfur coals.

The following, Mr. Chairman, are some specific budget recommendations that GRI would make.

In the area of unconventional natural gas, we would recommend $4 million in the DOE budget for western tight sands. GRI has got a budget of $10 million in 1990 in this area, mostly in the blanket sands. We would recommend that DOE work be conducted in the lenticular sands.

In the area of eastern Devonian shale, we would recommend a budget of $4 million. There is over 120 trillion cubic feet of gas in place in the heart of the Appalachian basin, and of this, up to 50 trillion cubic feet is estimated to be recoverable with advanced technology. GRI has a budget of approximately $5.5 million. We would recommend a budget of DOE of $4 million to focus on directional drilling applications.

The third area, in unconventional gas, would be secondary gas recovery where we would recommend a budget of $3 million. A significant quantity of natural gas is known to exist in currently producing in abundant fields. We started a cooperative R&D venture in 1988 to conduct field experiments on producing bypass gas in known fields. We will be contributing over 50 percent of the cost. DOE funding of $3 million is required in 1990 to continue this joint program as scheduled.

Another area we would like to recommend is fuel cells, a budget of $36.5 million. Installed on-site, fuel cell power plants can supply all or part of the electricity and heating requirements with very high overall efficiencies, good reliability, low noise and virtually no pollutants.

Two types of advanced fuel cells appear promising. We think DOE should fund $10 million of research in solid oxide technology and $20 million to continue the three competitive proposals in the molten carbonate area.

In the area of phosphoric fuel cells, which is winding down, we would recommend that DOE maintain a generic program of about $2.7 million.

My last specific recommendation is in combustion systems emissions control in the coal combustion area where we would recommend $2 million. Laboratory tests have indicated that technologies which combine gas with coal can show a reduction of 60 percent in NO_x and 50 percent in SO_2 when you use as little as 15 percent of gas as a supplemental fuel in the boiler. In addition to significant NO_x and SO_2 reductions, boiler operators may also realize substantial operating benefits. Furthermore, as I have earlier said, this may give us the ability to continue to use some of our high sulfur coal at older, smaller power plants that it is just not economically feasible to add scrubbers.

Over the next five years, GRI plans to spend $15 million for research and development of these technologies. We think the next step is to expand a full scale testing. We would recommend DOE fund $2 million in 1990 to initiate a gas reburn demonstration at a host utility.

In summary, Mr. Chairman, GRI recommends DOE fund a gas-related budget in fossil energy of $73.4 million while we fund near-term research in these same program areas of the budget of approximately $69 million. We believe these central themes of fund-

ing adequate long-term gas research in DOE while GRI funds near-term research to give us the technology to substitute abundant domestic gas for imported oil and to act and assist in mitigating environmental concerns for sound, national energy policies that Congress should give serious consideration to.

Thank you very much, Mr. Chairman.

[The prepared statement of Mr. Webb follows:]

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT
POLICY AND REGULATORY AFFAIRS
GAS RESEARCH INSTITUTE
ON THE DOE FY 1990 GAS-RELATED FOSSIL ENERGY RESEARCH BUDGET
BEFORE THE COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE
JULY 11, 1989

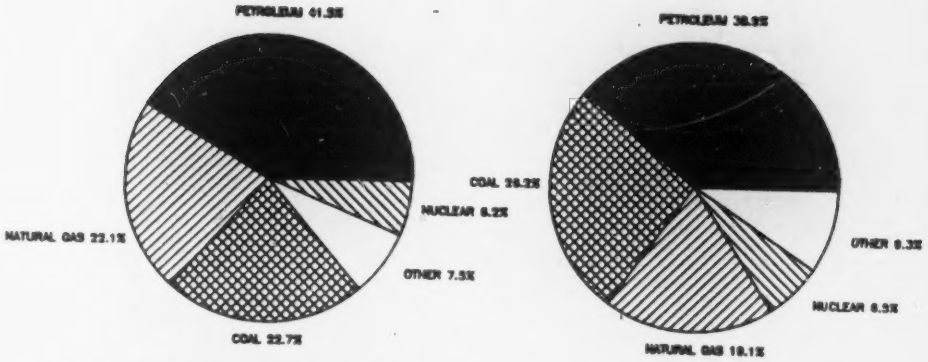
I appreciate the opportunity to appear before you today to present Gas Research Institute's (GRI) recommendations on budget and program priorities for gas-related research in the Department of Energy's (DOE) FY 1990 Fossil Energy Program. The recommendations reflect the minimum funding required for a viable gas research program in DOE. In developing these recommendations, GRI gave top priority to three considerations: (1) the need to develop the United States' extensive domestic gas resources; (2) the urgent requirement to reduce our dependence on imported oil; and (3) the critical role gas can play in helping to solve some of our environmental problems. GRI and the gas industry have agreed upon a recommendation of $73.4 million for gas-related research in DOE's FY 1990 Fossil Energy Program. Central to the gas industry's recommendation is that GRI is planning to commit $69.1 million to research in the same program areas in 1990. Essentially, GRI is proposing that DOE's gas-related budget in FY 1990 approximately equal GRI's research budget in these same program areas.

GRI is an independent, not-for-profit scientific research organization that plans, manages, and finances a cooperative R&D program for the benefit of its 308 members and their customers. The R&D program is implemented through contracts with research organizations, engineering firms, universities, energy companies, and manufacturers. National energy R&D policy is a major factor influencing the R&D program since GRI cofunds and coordinates many of its research projects with DOE. GRI estimates it will coordinate $30 million of research with DOE in gas-related programs in 1990. Therefore, congressional action on the proposed FY 1990 budget has a direct impact on the gas industry's R&D program.

U.S. ENERGY OUTLOOK

The necessity of continuing a viable gas-related federal energy R&D policy becomes evident when we examine where the U.S. is projected to get most of its energy supplies over the next 25 years. U.S. actual primary energy consumption in 1987 relied on gas and oil to meet 63 percent of demand. GRI's projections indicate that in the year 2010, the U.S. will still get 58 percent of its energy from oil and gas. (See Exhibit 1.)

Exhibit 1
U.S. Primary Energy Consumption



1987 ACTUAL PRIMARY ENERGY CONSUMPTION *
(TOTAL 79.3 Quads)
*Source 1988 GRI BASELINE PROJECTION

2010 PRIMARY ENERGY CONSUMPTION*
(TOTAL 99.8 Quads)

Last year the American Petroleum Institute released a report that showed the number of wells drilled in search of oil and gas in 1987 declined more than 10 percent from 1986 levels and more than 60 percent from the drilling peak of 91,000 wells in 1981. By 1986 only 35,000 wells were drilled. U.S. oil production plummeted by 400,000 barrels a day during 1987 to a total of 8.28 million barrels per day. Meanwhile, U.S. consumption increased by 300,000 barrels per day, or by more than 5 percent. The reduced U.S. production and increase in consumption are forcing the United States into an even greater dependence on foreign oil, most of which is produced in the volatile Middle East. Imports now account for approximately 43 percent of U.S. consumption. This is the highest oil import level since the end of the 1970s.

While it is unreasonable to assume that the U.S. can become completely energy independent in the near- or mid-term, several options are available to ease the high import level. One obvious option is to substitute natural gas in viable areas that are currently adding to the oil imports. These applications include natural gas vehicles, combined-cycle power generation, cogeneration, and many commercial- and residential-size heating and cooling applications.

Why is substituting natural gas for imported oil a feasible U.S. energy policy option? Because the U.S. natural gas resource base is huge. With advances in technology, gas will maintain an important role in a highly competitive future U.S. energy mix well into the next century (See Exhibit 2). This future depends on continuing funding for a viable federal/gas industry research program to produce the technology base necessary to develop plentiful cost-competitive gas supplies and more efficient appliances, equipment, and gas processes. Developing this technology base requires a five- to ten-year lead time and a joint DOE/gas industry effort.

Exhibit 2
Total United States Gas Reserves and Resources 1/

	Technically Recoverable Gas, Tcf	Recoverable Gas by Price $3/Mcf	$3-$5/Mcf
Lower 48 (Conventional)			
Proved Reserves	159	159	--
Inferred Reserves	227	164	18
Gas Resources Associated with Oil	61	30	11
Undiscovered	353	142	87
Subtotal	800	495	116
Lower 48 (Unconventional)			
Gas in Low-Permeability Reservoirs	180	70	49
Coalbed Methane	48	8	4
Shale Gas	31	10	5
Subtotal	259	88	58
Alaska			
Reserves	33	7	0
Inferred	96	5	2
Subtotal	129	12	2
Total	1,188	595	176

1/An Assessment of the Natural Gas Resource Base of the United States, prepared by Argonne National Laboratory for U.S. Department of Energy Office of Policy, Planning, and Analysis, May 1988

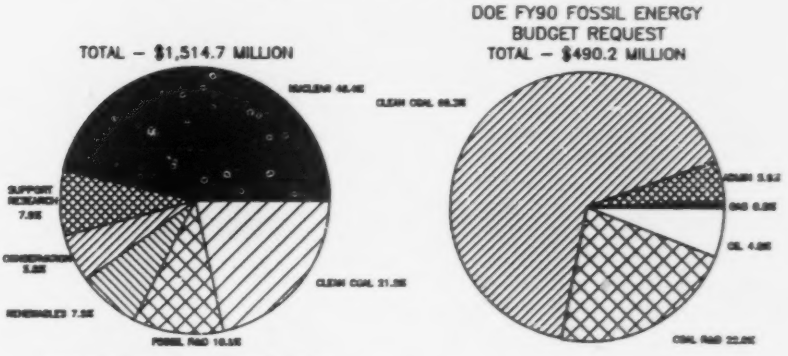
DOE ENERGY POLICY STATEMENTS VS. BUDGET REALITY

In February 1988 DOE announced a major new study to perform a comprehensive assessment of U.S. natural gas reserve potential. In announcing the study, Secretary Herrington stated, "Our growing dependence on imported oil is an Achilles heel." He further stated, "This is an opportune time to reassess the role natural gas can play in displacing imported oil."

The DOE Energy Security Study released last March concluded U.S. oil imports will probably increase substantially by 1995. Projections range from 8 million to 10 million barrels per day. The study also concluded that abundant domestic natural gas is the fuel that is most readily substitutable for oil. The study indicates targeted R&D in unconventional gas is one critical step to reducing U.S. dependence on imported oil.

Also, last May DOE performed a detailed assessment of total gas reserves and resources. The results (see Exhibit 2) show that over 1000 Tcf of gas is technically recoverable with approximately 600 Tcf recoverable by using advanced technology at prices of $3/Mcf. Included in this recoverable gas is 259 Tcf in unconventional reservoirs. Notwithstanding these DOE policy statements and gas resource study findings, the DOE FY 1990 budget request is totally inconsistent with policy recommendations and the potential for gas to play a vital role in the U.S. energy future. The total budget request for gas-related research in DOE's Fossil Energy Program is only $25.7 million, a reduction of nearly 60 percent from the $62.2 million Congress appropriated last fall. The request for unconventional natural gas R&D is only $4.1 million, less than 1 percent of the proposed Fossil Energy budget. The budget as submitted does not support the policy of allowing gas to play an important strategic role in reducing U.S. dependence on oil imports and solving environmental concerns. (See Exhibit 3.)

Exhibit 3
DOE's Program Is Out of Balance When Compared With
the Present and Future Energy Needs of the Nation



1990 DOE R&D FUELS BUDGET REQUEST
(EXCLUDING BASIC R&D, DEFENSE,
WASTE AND REMEDIAL ACTION,
AND BUSINESS ENTERPRISES)

PROPOSED JOINT DOE/GAS INDUSTRY GAS RESEARCH PROGRAM

An expanded joint effort between the gas industry and DOE is needed to ensure a stable, reliable energy mix for this nation's security. To maintain this joint effort, GRI recommends $73.4 million for DOE's gas-related research budget in Fossil Energy. In many cases, these projects are being coordinated or cofunded with gas industry funding. GRI encourages greater use of cooperative R&D ventures to conduct much of this research especially in unconventional natural gas. Congress has recognized the need for a viable DOE gas-related program and has appropriated approximately $60 million to $65 million each year for these DOE programs. (See Exhibit 4).

Exhibit 4
Gas-Related Research Recommendations
for DOE FY 1990 Fossil Energy and Conservation Programs
($ Millions)

	FY 1988 Approp.	FY 1989 Approp.	FY 1990 Gas Industry Recommend.	GRI Planned Budget 1990 1/
Fossil Energy				
ARTD (Gas-Related)	$ 6.0	$ 6.00	$ 6.0	$14.6
Fuel Cells (Gas-Related)	20.5	17.03	36.5	3.5
Coal Gasification	24.2	23.82	5.9	1.9
Combustion Systs. Emission Control	0.0	0.00	2.0	5.2
Heat Engines (Gas-Fueled)	3.0	3.00	8.0	5.5
Unconventional Natural Gas	10.9 2/	12.38 2/	15.0	38.4 3/
Fossil Energy Total	$64.6	$62.23	$73.4	$69.1

1/Preliminary estimate--not yet FERC-approved
2/Includes geoscience activities
3/Includes $3.6 million for geosciences

The GRI planned budget for 1990 in Exhibit 4 reflects only a partial picture of the gas industry's R&D effort. GRI's total 1990 R&D contract budget is $153.5 million. In addition to gas supply research, the R&D program includes research on more efficient and new uses of gas, more economical transmission and distribution of gas, and crosscutting basic research. (see Exhibit 5).

Exhibit 5
GRI R&D Programs

	1989		1990*	
	Budget ($M)	Percent	Budget ($M)	Percent
Supply Options	39.97	27.2	44.52	29.0
End Use	80.95	55.2	81.79	53.3
Gas Operations	20.28	13.8	21.59	14.1
Crosscutting Research	5.50	3.7	5.60	3.6
	146.70	100%	153.50	100%

*Preliminary estimate--not yet FERC-approved

GRI's R&D program helps to assure, both now and in the future, the widest use of natural gas that is consistent with a least-cost energy strategy. Major emphasis is placed on the development of technologies that have the potential to increase the efficiency of using natural gas in existing applications, and that are critical to new, cost-effective applications in which economic or other advantages can be identified. More specifically, GRI's program is designed to:

1. Decrease the cost of producing and delivering gas;

2. Enhance the role of gas in providing least-cost energy services, recognizing the importance of maintaining and increasing the superior quality, convenience, safety, and reliability of gas energy service at competitive prices;

3. Facilitate the transfer of new technology and technical and scientific information to the gas industry and its customers; and

4. Stimulate innovation in gas-related technologies through a mission-oriented basic research program.

RECOMMENDED GAS POLICY INITIATIVES

1. Establish an Office of Assistant Secretary for Natural Gas and Oil

In order for natural gas and oil to assume a more vital and important role in government energy policy, it is time for greater emphasis to be placed on activities related to natural gas and oil. GRI supports the gas industry's proposal to the Administration to create the post of Assistant Secretary of Natural Gas and Oil within DOE. This official would have overall responsibility for coordinating gas and oil research and policy within DOE and the government as a whole.

Natural gas and oil provide over 65 percent of current U.S. energy and are projected to provide over 50 percent of U.S. energy in 2010. Yet the DOE Fossil Energy budget devotes less than 6 percent of its funding to R&D for these two resources. We must have a better balance between U.S. energy use and energy R&D funding if the U.S. is ever going to develop a rational energy policy. The establishment of an Office of Assistant Secretary for Natural Gas and Oil would demonstrate a commitment to a rational energy policy and would promote the visibility and public understanding that gas and oil issues require.

2. Continue and Expand Cooperative R&D Ventures

GRI encourages DOE and Congress to continue and to expand the concept of cooperative R&D ventures between industry and government. We believe the current cooperative R&D venture with GRI, the State of Texas Bureau of Economic Geology, gas producers, and DOE in secondary gas recovery is an

example that could be expanded to other areas in the Fossil Energy Program. The most effective technology transfer occurs when industry is involved early and substantially from both cost and technical aspects in a research and development effort. The more directly the research agenda is guided by the companies' own technological and economic needs, the more effective transfer is likely to be.

While the cooperative venture concept is still a relatively new approach to government-industry financial partnerships, it is one that gives the private sector greater incentive to carry out research programs that are responsive to its R&D needs. Through industry's willingness to invest its own resources (at least 50 percent of the project funding), the research is managed and directed in a responsible way. In short, a joint R&D venture offers a relatively low-cost route to innovative technology through pooling government and industry resources.

GRI particularly recommends cooperative R&D ventures in geosciences, unconventional natural gas, and combustion turbines or heat engines. GRI is prepared to initiate discussions with DOE on cooperative R&D ventures in these technologies if Congress provides funds.

3. Recognize Role of Gas in Clean Coal Technologies

Federal policy has long overlooked the significant role natural gas can play in helping the nation use coal in an environmentally acceptable manner. In fact, for near-term and many retrofit applications, gas used in combination with coal combustion systems is probably the best solution.

Natural gas is our nation's cleanest fossil fuel. Its combustion emits virtually no particulates, sulfur oxides, or reactive hydrocarbons, and it produces far lower emissions of nitrogen oxides and carbon monoxide per unit of energy than coal or oil. Used selectively with coal, relatively small quantities of natural gas could contribute significantly to protecting our air quality at a low cost. Given the size of the gas resource base and the economics of gas production, the competitive position of gas relative to other environmental control options should remain favorable. In addition, a million-mile pipeline and distribution network is already in place. Thus cost-effective solutions to using coal cleanly are both possible and practical by selectively using natural gas.

Gas can be used for simultaneous combustion of gas and coal in a single combustor; and it can be used in flue-gas cleanup systems as a transport mechanism for sorbent injection to reduce SO_2 and in a reburn mode to reduce NO_x. The use of gas as part of the overall approach to controlling flue-gas emissions during coal combustion should be one element of national energy policy.

On April 24, 1984, the Secretary of DOE asked the Energy Research Advisory Board (ERAB) to convene a panel to assess the principal technologies for the clean use of coal. The ERAB panel completed its assessment in 1985.

These findings are still relevant in any review of the nation's clean coal technology program:

a. Coal use in the U.S. is expected to continue to increase for most of the next 25 years.

b. The two major factors influencing this trend are the low price and the abundance of domestic coal and the reduced contribution of nuclear power.

c. Direct combustion of coal will continue to represent over 90 percent of all coal use for the rest of the century and beyond.

d. The number of specific coal-use situations is so large and diverse, and the specific problems are so site-specific that no generally applicable solution can be presented. This issue is even more difficult when applied to retrofit situations which represent the overwhelming majority of applications.

The ERAB panel made three specific recommendations in its report to DOE that clearly indicate the importance it assigns to retrofit clean coal technologies that use high-sulfur coals.

a. Early demonstration of retrofit technology is most urgent.

b. It is important to make sure that the high-sulfur coals that can be mined at a relatively low cost are given priority for the test work. This includes coals from areas such as Kentucky Nos. 9 and 11 seams, Illinois and Indiana Nos. 5 and 6 seams, and Ohio and West Virginia Pittsburgh seams.

c. The basic goal of the research will not be achieved unless we can apply new processes to the high-sulfur coals.

Federal policy has long overlooked the significant role natural gas can play in helping the nation use coal in an environmentally acceptable manner. Therefore, it is particularly encouraging to GRI and the gas industry that ERAB emphasized the urgency of demonstrating retrofit technologies in its report to DOE. In fact, for many near-term retrofit applications, gas used in combination with coal in both industrial and utility combustion systems has the potential to be the most cost-effective solution.

RECOMMENDED DOE FY 1990 GAS-RELATED RESEARCH

Budget request levels continue to be far below what is necessary to conduct critical gas-related R&D in fossil energy, and for the past five years, Congress has consistently increased this budget area to provide a viable funding level for ongoing research. In order to attract industrial funding partners in this research effort, it is necessary to maintain a continuity in funding and support for these ongoing programs. In its recommendations for

gas-related research, GRI and the gas industry have, for the most part, requested a maintenance of ongoing programs supported by Congress in the past. But as public attention focuses on environmental issues such as acid rain and global warming, it is time to increase R&D in those areas that utilize natural gas to address environmental needs. The gas industry, through GRI, is investigating technologies to reduce emissions from combustion by using gas in combination with other fuels such as coal and oil. Therefore, some increase over past years' recommendations is reflected in unconventional natural gas research, research on combustion systems emissions controls, and research on heat engines.

Following is a recommendation for specific programs of particular interest to GRI.

FOSSIL ENERGY

	FY 1988	FY 1989	FY 1990
Western Tight Sands	Appropriation	Appropriation	Recommendation
	$3.3 Million	$3.325 Million	$4.0 Million

Significant amounts of potentially recoverable natural gas exist in low-permeability sandstone formations located in sedimentary basins throughout the United States. Current information indicates that the total amount of economically recoverable gas from tight sands could be in excess of 500 Tcf. However, a combination of technical limitations and economic constraints prevent the widespread commercial exploitation of these resources. It is estimated that the development of advanced technologies and practices applicable to tight gas sands could provide an additional 180 Tcf of cost-competitive gas over what is recoverable with the present state-of-the-art technology.

Gas-bearing tight sands occur in the form of blanket-type and lenticular formations. In both types, the effects of a variety of interdependent parameters are still unknown, and consequently, the gas recovery rate and active reservoir life for a given field remain uncertain. To permit low-cost exploitation of the full potential of the tight sands resource base, the following specific technological issues need to be addressed:

1. Determine the relationship between geologic and engineering parameters;

2. Further characterize tight sands gas reservoirs and improve resource estimates;

3. Identify the parameters critical to formation evaluation and gas production;

4. Understand more clearly the mechanisms of hydraulic fracture propagation and control;

5. Diagnose fracture shape and downhole conditions using surface parameters;

6. Provide real-time fracture treatment design changes; and

7. Apply advanced technologies to presently noncommercial areas.

Geotechnical and economic analyses have demonstrated that blanket-type formations are more amenable in the near term because the geologic environments in which they exist are less complex than the environments associated with lenticular formations. Therefore, GRI has concentrated its efforts in the near-term aspects of blanket-type formations such as resource characterization, formation evaluation, fracture diagnostics, and real-time analysis development. In addition, in 1989 GRI plans four staged field experiments to validate technologies developed in this project area. GRI's planned 1990 budget for tight gas sands is $10.9 million. In addition, it is expected that industrial partners will contribute another $4.25 million. GRI recommends that DOE commit $4.0 million for longer-term research in the lenticular formations.

Eastern Devonian Shales	FY 1988 Appropriation	FY 1989 Appropriation	FY 1990 Recommendation
	$2.3 Million	$3.075 Million	$4.0 Million

The large eastern Devonian gas shales resource base underlies approximately 175,000 square miles of the Eastern United States. Current information indicates that the gas-in-place is approximately 2000 Tcf; however, large uncertainty exists regarding how much of that resource may be recoverable. There is approximately 120 Tcf of gas-in-place in a drillable area of 22,000 square miles in the heart of the Appalachian Basin, and projections indicate that up to 50 Tcf of gas may be technically recoverable.

In general, two major factors constrain present-day exploitation of this resource: (1) the inability to predict with confidence the gas production rates that will be obtained in wells drilled outside of historical production areas, and (2) the inconsistent response of formations to currently employed stimulation practices. Because most of the producers in the Appalachian Basin are small independents, they cannot afford to conduct the comprehensive R&D required to understand and solve these problems.

Barriers to economic production of natural gas from Devonian shales include:

1. Inadequate understanding of factors that control the flow of gas from Devonian shale formations to the wellbore;

2. Lack of effective exploration rationales to identify geographic areas and stratigraphic zones with highest production potential;

3. The need for improved diagnostic methods to assess the potential of productive zones;

4. Inadequate understanding of shale gas reservoir dynamics; and

5. Lack of generally effective stimulation techniques.

Economic exploitation of the full resources hinges on development of improved techniques and technologies for overcoming these limiting factors.

GRI's program in eastern Devonian shales includes reservoir evaluation, recovery enhancement methods, geologic production controls, and development of a resource well information data base. GRI's planned 1990 budget for eastern Devonian shales is $5.5 million with an additional $3.1 million in industrial funding expected. The gas industry recommends a total of $4.0 million for DOE research of eastern Devonian shales focused on directional drilling.

Secondary Gas Recovery	FY 1988 Appropriation	FY 1989 Appropriation	FY 1990 Recommendation
	$2.5 Million	$2.5 Million	$3.0 Million

A significant quantity of natural gas requiring minimal exploration and in close proximity to gathering systems and pipelines is known to exist in currently producing and abandoned wells and fields. These potential reserve additions consist of (1) bypassed gas in currently producing or temporarily abandoned wells, (2) reservoir compartments in existing fields, and (3) gas trapped by the encroachment of water in water-drive reservoirs.

To ensure the timely development of technologies for near-term production of bypassed gas and gas from undiscovered reservoir compartments in developed fields, the following specific technological issues need to be addressed: (1) improved understanding of geologic environments and characteristics of gas fields to allow for more accurate resource identification and estimates, (2) provision of an accurate methodology for cased-hole formation evaluation, and (3) development of in-field reexploration rationales based on a better understanding of reservoir heterogeneities. By addressing these issues, gas producers can exploit appropriate elements of the conventional resource base in the near term at market-clearing prices. Over the longer term, application of these technologies can increase gas reserves and deliverability of low-cost gas through more effective and efficient development of fields yet to be discovered.

In addition to bypassed gas and gas from undiscovered reservoir compartments in developed fields, an estimated 500 Tcf of technically recoverable natural gas (50 Tcf of which is estimated to be economically recoverable) exists in water-drive reservoirs in the form of trapped gas. The gas becomes trapped as a result of the encroachment of water into production wells and the inability to maintain low reservoir pressure due to high water influx into the reservoirs. Once high levels of water production are reached, the traditional production practice is to plug and abandon the affected gas wells and ultimately the gas field. Recent data have indicated that the recovery efficiencies for the prolific water-drive gas reservoirs along the Texas-Louisiana Gulf Coast are now recognized to be 50 percent or less.

Currently, GRI's program addresses resource characterization, coproduction of trapped gas and water, and brine treatment and control. An initiative undertaken in 1988 was research into the undiscovered reservoirs in known fields. This Secondary Gas Recovery program is cofunded with the Department of Energy, GRI, the State of Texas Bureau of Economic Geology, and producers under a cooperative R&D venture.

GRI's planned 1990 budget for secondary gas recovery is $6.7 million with an additional $3.0 million expected from industry. The recommended DOE funding is $3.0 million to meet the commitments of the cooperative R&D venture.

Underground Coal Gasification	FY 1988 Appropriation	FY 1989 Appropriation	FY 1990 Recommendation
	$2.825 Million	$1.371 Million	$2.5 Million

Underground coal gasification offers a method for recovering coal resources, without the need for mining, by gasifying the coal in-place underground. Oxygen, in conjunction with steam, is injected into an underground coal bed to drive and control the gasification reactions. As a potential source of cost-competitive pipeline-quality gas, in situ coal gasification may be able to tap those vast coal deposits that would not normally be economically recoverable using existing or anticipated strip- or deep-mining methods. Underground coal gasification is, therefore, applicable to a different coal resource base than surface gasification. In comparison with present-day surface gasification processes, underground technology offers a projected 15 to 35 percent cost savings as well as possible environmental and safety advantages.

At the present time, underground coal gasification must be classified as a high-risk, advanced technology, but one with very high payoff potential. This high payoff would be due at least in part to the very large potential resource base to which this technology can apply. DOE has estimated that, of the current 6.4 trillion tons of domestic coal resources, only about 0.5 trillion tons are currently economically recoverable by existing surface- and deep-mining techniques. Underground coal gasification could potentially utilize about 1.8 trillion tons, producing more that 1000 Tcf of substitute natural gas, even if only 10 percent of this resource is suitable for gasification.

Major challenges confronting successful development of in situ gasification include: (1) the verification of low-cost, reliable, reproducible methods for providing a pathway linking injection and production wells; (2) control of the combustion front and gas quality; and (3) prediction and mitigation of subsidence potential and other environmental impacts. In particular, additional R&D is needed to further prove the applicability and reliability in the field of the low-cost, controlled-retracting-injection-point (CRIP) concept developed by Lawrence Livermore National Laboratories. This concept provides the capability of reducing cavity and roof interactions (which can decrease gas quality during the burn) by controlled relocation of the burn cavity within the coal seam when cavity/roof interactions begin. The first large-scale test of the CRIP technology--a 30-day test at Centralia,

Washington, under DOE and gas industry sponsorship--was successfully completed in 1983. A large-scale test (conducted for 100 days by GRI as the head of an industry consortium in conjunction with DOE at Hanna, Wyoming, during late 1987 and early 1988) assessed the technology further. The test results defined the viability of the CRIP process for the cost-effective recovery of subbituminous unmineable coals in flat coal seams.

Continued DOE support is needed to do post-burn coring and generic environmental work at the Rocky Mountain I site, analysis of RMI data by Lawrence Livermore National Laboratory, completion of treatment of the abandoned Hoe Creek UCG site, and planning for follow-on UCG environmental research.

GRI's 1989 budget for underground coal gasification is $725,000, and GRI's planned budget for 1990 is $450,000. The recommendation for DOE's FY 1990 budget is $2.5 million.

Fuel Cells (Gas-Related)	FY 1988 Appropriation	FY 1989 Appropriation	FY 1990 Recommendation
	$20.45 Million	$17.034 Million	$36.5 Million

A fuel cell uses natural gas in an electrochemical process to produce electricity and heat. This is accomplished with very high overall energy efficiency, good reliability, low noise, and virtually no pollutants. The gas utility industry, in cooperation with other parties, has supported the development of onsite phosphoric acid fuel cells for the past two decades as alternatives to existing prime-mover-powered cogeneration systems for use in commercial and industrial cogeneration applications. Two developments have made clear that the technology base for an early-entry fuel cell power plant is presently well defined: (1) the successful field testing (from 1983-1986) of 46 40-kW fuel cell systems and (2) the decision by the participating manufacturer to commercially offer larger phosphoric acid fuel cell (200-kW) power plants for delivery starting in 1990 or 1991. R&D is still warranted, however, to reduce the capital cost and increase the performance and durability of phosphoric acid fuel cell systems to levels acceptable for commercial viability. Early-entry systems of this type will serve to introduce the fuel cell concept to a wide range of potential users.

Advanced fuel cell technology, currently being addressed by several organizations worldwide, offers three important operating benefits compared with phosphoric acid fuel cells: (1) electrical efficiencies of 45 to 63 percent (compared with 36 percent for phosphoric acid fuel cells), (2) higher temperature operation (1300°-2000°F vs. 400°F) offering higher-quality thermal energy, and (3) ability to use natural gas directly without extensive reformer equipment. Two types of advanced fuel cells appear promising: the solid oxide (ceramic) fuel cell (SOFC) and the carbonate fuel cell (CFC). SOFC technology is promising because of its potential for high-power-density cell stacks, its solid state construction which eliminates the liquid electrolyte, and its potential as a simpler and less expensive system than the carbonate type. Major R&D efforts are needed, however, on cell fabrication technology and durability before detailed SOFC system development can be undertaken.

Research on CFC technology is being conducted by several organizations in the United States and Japan for use primarily on central-station electric generation. GRI has monitored the progress being made in this research, especially with regard to potential application of carbonate technology in an onsite cogeneration system. Although the development of CFCs has proceeded further than solid oxide systems, major development efforts are still needed in the cell stack area (power section) before the CFC can be commercialized. These efforts include activities that have long development times and represent major technological hurdles: electrode performance and durability, electrolyte management, corrosion, thermal cycling, integration of stack components, and improved fabrication technologies.

GRI's planned 1990 budget for fuel cell activity is $3.5 million with an additional $3.4 million from industrial partners. The gas industry recommends a DOE budget of $36.5 million for molten carbonate and solid oxide fuel cells and for a generic program in phosphoric acid fuel cells.

	FY 1988	FY 1989	FY 1990
Combustion Systems	Appropriation	Appropriation	Recommendation
Emissions Control	$0.0 Million	$0.0 Million	$ 2.0 Million

The role of gas is often overlooked in any discussion of a clean coal technology program, yet documented laboratory research results indicate for existing power plants the use of gas in combination with coal may be the most cost-effective retrofit approach to simultaneously reducing nitrogen oxide (NO_x) and sulfur dioxide (SO_2) emissions from flue gases. Research sponsored by Gas Research Institute (GRI) over the past three years as part of an Environmental Protection Agency (EPA) research project clearly illustrates that gas-enhanced emission control is one of the most promising near-term clean coal technologies, especially for retrofitting existing coal-fired boilers.

Laboratory tests of these technologies show a 60 percent reduction in NO_x and a 50 percent reduction in SO_2 can be obtained by using 15 percent gas in a coal-fired boiler. The next step is a demonstration of these gas-enhanced technologies in retrofit applications in utility and large industrial boilers. If the demonstrations are successful, the gas-enhanced emission control processes will provide an extremely cost-effective solution for simultaneously reducing SO_2 and NO_x emissions. For this reason, I urge the members to consider the critical contribution gas can pay as part of the solution to clean coal combustion.

One of the more promising SO_2 control strategies is to inject calcium-based sorbents into the combustion chamber to capture the sulfur prior to the boiler outlet. This process was investigated in the late 1960s and was abandoned because it could not achieve the desired SO_2 control and also tended to create operational problems. Recently, there has been sufficient incentive to reexamine the limestone injection process (LIMB) as a cost-effective retrofit alternative for acid rain precursor control. The EPA's efforts in recent years have focused on the development of this technology for coal-fired boilers.

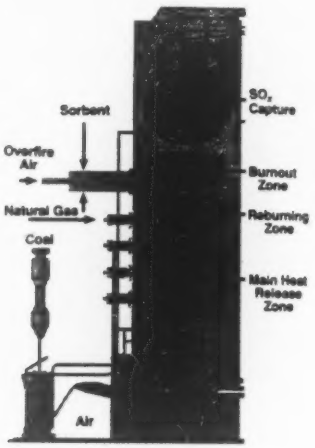
GRI's program has been to enhance the cost-effectiveness of this technology through the use of gas combustion technology. Gas may offer improved sorbent injection performance benefits by more effectively controlling the conditions at which limestone sorbent is calcined and mixed with the coal combustion flue gases; it may help to avoid coal-ash/sorbent interaction problems that decrease sorbent surface area; it can be used more effectively to optimize the temperature profile of the sulfation zone where sulfur capture occurs; and it reduces the amount of sorbent material needed.

Nitrogen oxide emissions are also considered, although historically to a lesser extent, as a contributing factor to acid deposition. The attention to NO_x as an acid deposition processor is increasing as scientific evidence tends to indicate that both SO_2 and NO_x are contributors. The formation of NO_x during the combustion of fossil fuels can be minimized by appropriate modification of the combustion process.

GRI is funding research on a new NO_x control strategy which involves in-furnace NO_x reduction by creating a transient reducing zone within the boiler. EPA has been conducting research programs to evaluate the potential of this technique for application to U.S. boilers. The term "reburning" has been coined in the U.S. to refer to this process. When using gas as the reburn fuel, it appears that this technology is capable of reducing NO_x by approximately 50 to 60 percent beyond a boiler's current emission levels. The specific technical benefits of using gas as the reburning fuel are that gas can be broadly retrofitted to existing boilers and can be applied without the combustion problems associated with coal firing in upper boiler regions; gas allows lower exhaust NO_x emission levels to be achieved since it is nitrogen free; and gas avoids the presence of molten ash in the superheater boiler region, thereby minimizing slagging and fouling problems.

Exhibit 6

NATURAL GAS REBURN—
FOR A WALL FIRED BOILER



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Potential benefits of gas use are both environmental and economic. The development of more cost-effective SO_2, NO_x and combined SO_2/NO_x control technologies using gas would lower energy costs and improve air quality. The economic benefits are broad based and provide an alternative to high-cost flue-gas scrubbing technologies. In addition to the significant NO_x and SO_2 reductions, boiler operators may also realize substantial operating benefits (mitigation of boiler derating, particulate control, and reduction of availability problems, etc.) by implementing gas-enhanced reburn/sorbent injection techniques. Furthermore, the gas-enhanced technologies would increase our ability to use the nation's high-sulfur coal resources and would decrease our dependency on imported oil. The environmental payoff is a significantly reduced quantity of pollutants emitted by coal or oil burning.

To summarize, gas has the unique advantage of allowing the simultaneous application of reburn and sorbent injection technologies in the same boiler. Over the next five years, GRI plans to spend over $15 million to support research and development of the reburn/sorbent injection technology for application to industrial and utility boilers. By using natural gas to enhance reburn/sorbent injection technology, GRI's goal is to provide greater than 60 percent NO_x and 50 percent SO_2 emission reduction while offering cost advantages over competing wet scrubbing technology. Different technology variations are being explored at both bench and pilot scales. The next step is to expand full-scale testing of reburn technology and gas-enhanced sorbent injection technology. GRI recommends DOE funding of $2 million in 1990 to initiate a gas reburn demonstration at a host utility site.

SUMMARY

GRI recommends that the Department of Energy continue to fund a viable, consistent gas-related research program that adequately addresses the long-term needs of this nation's energy supply and environmental concerns. A total of $73.4 million would continue the fossil energy programs Congress has already approved in past years. We believe this budget recommendation is consistent with the realities resulting from the large budget deficit and the need for a balanced energy policy. It should be noted that the gas industry is funding near-term research in these program areas with a GRI R&D budget of approximately $69.1 million.

These central themes of funding adequate, long-term gas research in DOE while GRI funds near-term research and of strengthening the environmental options for using coal by funding alternatives that combine gas and coal combustion are sound national energy policies that Congress should implement.

Exhibit 7
Recommended DOE Gas-Related Budget for FY 1990
for Fossil, Conservation, and Renewables R&D
($ Millions)

	FY 1987 Approp.	FY 1988 Approp.	FY 1989 Approp.	FY 1990 Gas Industry Recommend.
Fossil Energy				
ARTD	$ 8.6	$ 6.0	$ 6.00	$ 6.0
Fuel Cells (Gas-Related)	14.9	20.5	17.03	36.5
Heat Engines (Gas-Related)	0.0	3.0	3.00	8.0
Surface Coal Gasification	24.6	21.4	22.45	3.4
Unconventional Natural Gas	8.1	10.9 1/	12.38 1/	15.0
Underground Coal Gasification (Technology Base)	2.4	2.8	1.37	2.5
Subtotal	$58.6	$64.6	$62.23	$71.4
Combustion Systems Emission Control (Clean Coal Tech. Fund)	15.0	0.0	0.00	2.0
Fossil Energy Total	$73.6	$64.6	$62.23	$73.4

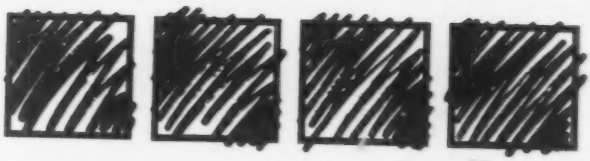
1/ Includes geoscience activities.

Natural Gas Use For Pollution Control

During the past several years, acid precipitation has emerged as an environmental issue with international implications. The term "acid rain" describes wet acidic deposition from the atmosphere, as well as dry deposition that behaves like acid rainfall when it contacts surface moisture such as lakes. The process of acid rain formation and deposition is quite complex and poorly understood. However, emissions of sulfur oxides (SO_x) and nitrogen oxides (NO_x) from large coal- and oil-fired boilers are generally recognized as playing a major role.

Natural gas as the cleanest burning fossil fuel can contribute to reducing harmful emissions of SO_2 and NO_x when used in combination with coal and oil. Natural gas technologies that are now being developed by the Gas Research Institute can play an important role in improving the quality of the environment. Successful research in such areas as gas reburning, gas cofiring and the combination of gas reburning with sorbent injection can significantly reduce emissions of SO_2 and NO_x. This will contribute to a cleaner and more healthy environment and at the same time provide the utility executive a cost-effective option to continue to use his current fuel of choice, e.g. locally available coal.

GRI
Gas Research Institute



The current concern over acid rain has resulted in proposals to substantially reduce SO_x and NO_x emissions from both industrial and electric utility boilers fired with fossil fuels. Present technologies for reducing these emissions from boilers fired with coal and oil are capital-intensive and have high operation and maintenance costs. If utilities are permitted the flexibility by any new emission control programs to make appropriate choices, natural gas has a role to play in reducing the emissions from these high-polluting boilers. The clean-burning qualities of natural gas present an opportunity to reduce NO_x and SO_x from existing boilers at a lower cost than alternative control technologies.

U.S. SO_x/NO_x EMISSIONS INVENTORY BY FUEL TYPE* 1980

	U.S. Fossil Energy Consumption (%)	SO_x (%)	NO_x (%)	SO_x and NO_x (%)
Natural Gas	30	Nil	15	7
Coal	23	80	33	58
Oil	23	18	28	23
Gasoline/Other	24	2	24	12
	100	100	100	100

*Source: EPA, President's Clean Air Proposal Fact Sheet

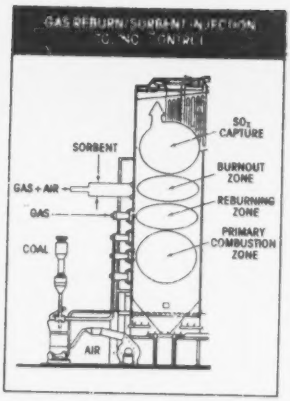
- Coal and oil combustion are the principal sources of SO_x and NO_x emissions in the U.S. from fossil fuel combustion (81%).
- Coal combustion alone accounts for 80% of the SO_x, 33% of the NO_x and 58% of the total SO_x and NO_x. Fifty coal-fired power plants are responsible for approximately one-half of all SO_2 emissions.
- Gas contributes only 15% to the NO_x and 7% of the total NO_x and SO_x emissions while accounting for 30% of the total fossil fuel energy consumption.
- Gas as the cleanest burning fossil fuel can be used in combination with coal and oil to reduce both SO_2 and NO_x emissions.

There are two ways in which gas may be applied to control emissions from electric generation plants:

- Gas can be used as a primary fuel to displace a portion of coal or residual fuel oil, either by firing a dual-fuel boiler intermittently with gas or by operating a parallel gas-fired boiler. In this scheme, known as select gas use, total emissions decrease **in proportion** to the amount of coal or residual fuel oil displaced.

- Gas in small quantities (10-15%) can be used as a supplementary fuel to reduce pollutants created in the primary combustion zone of a coal- or oil-fired boiler. Compared with select gas use, this technique, known as gas-enhanced combustion or cofiring, provides a **greater reduction** in emissions per unit of gas consumed.

Cofiring Technologies



- **Basic Cofiring**—While a plant is burning coal, one to ten percent natural gas is also injected into the combustion chamber. GRI conducted a field evaluation in cooperation with Consolidated Natural Gas Service Company, Inc. on a 570 MW power plant in Pennsylvania in which coal was cofired with varying amounts of gas. Not only was there a reduction of NO_x (10-20 percent) and SO_x (3-12 percent), the test also showed other advantages of cofiring, including clean and fast start-up, reduced slagging, and the ability to fire lower quality coals. The economic value for these benefits will be site specific.

- **Gas Reburn**—Natural gas (10-20%) is injected into the upper region of the furnace to create a fuel-rich zone in which NO_x is converted to molecular nitrogen. More air is added to burn out any unburned fuel at a temperature low enough to minimize further NO_x formation. Reburn provides 15 to 20 percent SO_2 reduction, 50 to 60 percent NO_x reductions and possible operational benefits. Gas reburn yields lower carbon monoxide concentrations, indicating more efficient combustion, and does not cause operational problems such as carbon burnout and slagging which are typically associated with coal use during reburn.

- **Gas Reburn/Sorbent Injection (GR/SI)**—Natural gas (15-20%) is used to carry a sorbent material into the combustion chamber. The sorbent material is used to capture SO_2 released from coal burned in the primary combustion zone. Combining natural gas sorbent injection with gas reburning provides 50 percent SO_2 and 60 percent NO_x reductions. As one of the original nine projects chosen under Round 1 of DOE's Clean Coal Technology Program, GRI is sponsoring a major field evaluation of gas reburn/sorbent injection technology in Illinois. The tests have indicated that the host utilities will be able to maintain their use of local, high sulfur coal.

In gas reburn/sorbent injection, SO_2 reductions believed achievable fall in the range of 40-60 percent, depending upon the type of sorbent material used and site-specific conditions. Gas consumption with GR/SI injection technology is about the same as reburn technology alone...nominally 15-20 percent of boiler fuel input. GR/SI is considered applicable to all boiler firing designs; it is more easily retrofitted than scrubber technology; and may offer some site-specific operational enhancements.

Applications of GR/SI, like most electric utility technologies, have to be assessed on a site-specific basis. Nevertheless, the best opportunities for applying GR/SI are projected to occur on medium to smaller size units (less than 500 MWs), trending to shorter economic lives, and experiencing moderate to lower capacity factors. Such units would typically have been built in the 1950's and 1960's and will not meet proposed clean air standards. Due to their age, these plants are not good candidates for capital intensive scrubbers.

GR/SI is envisioned to be a "bridging" technology providing utilities a cost effective means of retrofitting and operating older, existing units until they are replaced with new generating capacity that must meet stricter environmental New Source Performance Standards (NSPS).

These gas enhanced technologies are desirable in that they reduce emissions of both SO_2 and NO_x, are low in capital cost, do not displace large quantities of coal or oil, and provide the utility the option to continue to rely on the current fuel of choice for the major fuel source. At the same time, these technologies address the problem of pollution in a rational and economically attractive manner.

HOW DOES NATURAL GAS COMBUSTION IN VARIOUS EXISTING AND FUTURE APPLICATIONS COMPARE WITH OTHER FORMS OF ELECTRIC UTILITY COMBUSTION?

STACK EMISSIONS PROFILE
(Lbs/MWhr Electric Output)

	Efficiency	SO_2	NO_x	SO_2+NO_x
Cogeneration—Natural Gas (Turbine) (Electrical and Thermal Output)	75%	0	0.5	0.5
Combined Cycle—Natural Gas (25 ppm NO_x Guarantee)	43%	0	0.9	0.9
Combined Cycle—No. 2 Oil (0.3% S Oil) (55 ppm NO_x Guarantee)	42%	2.6	2	4.6
Combined Cycle—Coal Gas (IGCC)	36-42%	0.2-0.9	0.4-0.8	0.6-1.7
Boiler—Residual Oil (NSPS Design)*	34%	8	3	11
Boiler—Fluidized Bed Firing Coal (NSPS Design)*	34%	12	3	15
Boiler—Pulverized Coal w/Scrubber (NSPS Design)*	34%	12	6	18
Boiler—Pulverized Coal w/o Scrubber (Pre NSPS Design)* (2.5% S Coal)	35%	45	10	55

*NSPS = New Source Performance Standards

- More advanced gas-fired electric generation technologies provide not only superior emission characteristics, but significant improvements in efficiencies over existing pulverized coal fueled generation units.
- Newer gas-fired technologies (e.g. packaged cogeneration units) also allow easier siting in difficult areas, such as in urban environments, reducing electric transmission equipment costs.

Natural gas used in currently available technologies and in newer advanced technologies can be utilized to contribute to the improvement of our nation's air quality. For further information, please contact the Gas Research Institute.

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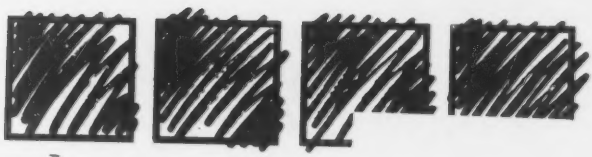

Senator FORD. Thank you, Mr. Webb.
Mr. Peters.

STATEMENT OF LEONARD K. PETERS, VICE CHANCELLOR FOR RESEARCH AND GRADUATE STUDIES, UNIVERSITY OF KENTUCKY

Mr. PETERS. Thank you, Senator Ford. Good afternoon, members of the subcommittee.

My name is Len Peters, and I am Vice Chancellor for Research and Graduate Studies at the University of Kentucky. In particular, my testimony addresses the Department of Energy's non-nuclear R&D program for oil shale research for fiscal year 1990.

Eastern oil shale is an enormous energy resource that will almost assuredly play a major role in meeting the energy and chemical feedstock needs of the Nation in the 21st century. It has been estimated that nationally this resource represents over 400 billion barrels of petroleum. This, as a liquid fuel source, is equivalent to 100 years using the U.S. current crude oil consumption rate as a basis.

Kentucky has an abundance of some of the richest of the eastern reserves. We have found the equivalent of over 16 billion barrels of oil on a narrow belt surrounding central Kentucky. This is equivalent to all of the oil in Texas and only includes shale that is on or near the surface and can be recovered easily with present day technology.

Kentucky has much at stake in eastern shale and has over the past decade put much effort into its study. In 1980 we conducted, along with two industrial partners, the first thorough study of the economic feasibility of eastern oil shale development. That study integrated technology assessment, mine design and resource assessment in a single effort.

The focus of our work has been to develop a fundamental understanding of the chemical and physical characteristics of eastern shale as applied to processing and environmental concerns. Very early our researchers learned that eastern shale is fundamentally different from that found in the western United States. Thus, the processes which exist for western shale are not appropriate for eastern shale.

Our research in Kentucky on advanced shale processing has contributed breakthroughs in the development of new technologies. A final spent shale which contains almost no residual carbon and sulfur and should therefore have no acid-generating capacity has been produced. We have demonstrated that KENTORT II, our technology, could completely recover the total energy potential of eastern oil shale while producing a spent shale with an enhanced environmental safety.

A larger system is essential if development of the process is to continue. Scale-up would also enable evaluation of commercial materials of construction, which is very important, and sufficient crude oil would be produced for upgrading studies.

The proposed research for fiscal year 1990 is the most cost effective plan possible consistent with the reasonable development rate and meeting the necessary technical criteria. And $375,000 is re-

quested for this effort. We will add a large increment of support from the energy laboratory at the University of Kentucky.

New technologies, such as KENTORT II, will produce spent shales which are physically and chemically different from those of the paste. In our opinion, the time to conduct research in this area is now, simultaneous with process development. When environmental solutions can be integrated into process design. For the past five years, our researchers have been studying the environmental characteristics of retorted eastern oil shale produced from a conventional technology originally designed for western shale. It is important that studies now be initiated on the disposal of spent shale having the characteristics of that from advanced technologies. The chemistry of the leachates generated under completely natural conditions will be determined over several seasons and the physical changes of the shale will be documented. Additional experiments can be conducted at the University of Wyoming indoor facility which allows extreme weather conditions that cannot be expected in a short duration field study.

A systems management model approach will be utilized which will make the information usable for other systems. It will have applicability to the management of other energy related solid wastes, including that from coal utilization. We are requesting $335,000 to begin this research. Again, a large increment of support from the University of Kentucky will be added to this effort.

Eastern oil shale represents an enormous energy potential of national importance. Research should be conducted now by making modest investments over a longer period of time to support a stable research program. We support overall an $8 million program for eastern oil shale research which includes the following three elements: $4.5 million to continue the process development research at the Institute for Gas Technology; $2 million to continue novel process development research, including our KENTORT process; and finally, $1.5 million for environmental studies for eastern oil shale. Funding at this modest level will enable research to be continued at several universities and laboratories across the Nation with the goal of exploiting and utilizing eastern oil shale as a valuable source of liquid fuel.

I appreciate this opportunity to present my views and also for the previous support provided by Congress to the eastern oil shale program. Thank you.

[The prepared statement of Mr. Peters follows:]

Statement
for
Senate Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
by
Leonard K. Peters
Vice Chancellor for Research and Graduate Studies
University of Kentucky
Lexington, KY 40506
July 11, 1989

Mister Chairperson and Members of the Subcommittee:

My testimony addresses the Department of Energy's non-nuclear R&D program for oil shale research for Fiscal Year 1990.

Eastern Oil Shale is potentially an enormous energy resource that will, with a very high degree of certainty, play a major role in meeting the energy and chemical feedstock needs of the Nation in the 21st century. It has been estimated that nationally this resource represents over 400 billion barrels of petroleum.

Kentucky has an abundance of some of the richest of the eastern reserves. Since 1980, we have drilled over 65 cores and completed tens of thousands of chemical analysis. Using rigorous standards, we have found the equivalent of over 16 billion barrels of oil in a narrow belt of twenty counties surrounding Central Kentucky. This is equivalent to all of the oil in Texas, and only includes shale that is on or near the surface and could be easily recovered with present day technology. These figures are much higher when considered in light of recent advances in oil shale processing.

Thus, Kentucky has much at stake in Eastern U.S. Oil Shale and has over the past decade put much effort into its study. In 1980, we conducted, along with two industrial partners, the first thorough study in the public domain of the economic feasibility of Eastern Oil Shale development. That study integrated technology assessment, mine design, and resource assessment in a single effort. Since then, the State of Kentucky has expended over $1.3 million dollars to co-sponsor, again with industrial partners, two pilot plant demonstrations of eastern U.S. shale. Kentucky has also developed and passed into statute a detailed set of environmental regulations for the mining of oil shale.

We have also provided a forum for Eastern Oil Shale research. For the past eight years, we have co-sponsored with industry, the Kentucky Department of Energy, and the U.S. DoE, the Eastern Oil Shale Symposium. Over 240 technical papers have been published from researchers world-wide from this symposium.

The focus of our work has been to develop a fundamental understanding of the chemical and physical characteristics of Eastern Oil Shale as applied to processing and environmental concerns. Very early, our researchers learned that Eastern U.S. Oil Shale is fundamentally different from that found in the Western United States. Eastern shale has a different type of kerogen, the solid material which generates the oil, and a different type of rock matrix.

Thus, the processes which exist for Western Shale are inefficient for Eastern Oil Shale. We also found that the standard techniques used for estimating oil yield of shale consistently underestimates that of Eastern Oil Shale.

Our initial studies concluded that advances in two research areas were critical to unlocking the energy potential of this resource. First, retorting technologies which are tailored to the unique characteristics of Eastern Oil Shale were needed; second, environmental research on the physical and chemical characteristics of retorted shale were necessary. Our experience in projects to commercialize oil shale earlier in the decade found that concern over the environmmental safety of the spent shale was the largest single impediment to the public acceptance of an oil shale energy industry.

Our research in Kentucky has contributed breakthroughs in the development of new processing technologies. In 1982, research at the Kentucky Center for Applied Energy Research discovered that the application of fluidized bed technology to Eastern Oil Shale pyrolysis resulted in yields much higher than expected. These findings were quickly confirmed at both the Lawrence Livermore Laboratory and at the Morgantown Energy Technology Center of the U.S. DoE.

However, the spent shale from fluidized bed processing was still high in sulfur and contained up to 50% of the original carbon as char. The sulfur can contribute to environmental problems in disposal, and the char represents wasted, unused energy. A long term program of research to solve these problems resulted in the formulation of the KENTORT II technology. This technology integrates three fluidized bed-based processing steps - pyrolysis, gasification, and combustion - into one thermally efficient process. In 1985 with additional support from the U.S. DoE, research to develop and prove the concept of this process was started using a small 5 pound per hour system.

In the unique KENTORT II process, recirculating shale from the gasifier provides the heat for pyrolysis, and 15-20% of the residual carbon left after pyrolysis is converted to a hydrogen-rich gas which can be used to upgrade the crude shale oils. Furthermore, the inorganic sulfur from the shale is removed as hydrogen sulfide; this can be converted to elemental sulfur. The removal of sulfur in this stage also reduces sulfur dioxide emissions from subsequent combustion. The final combustion stage burns the remainder of carbon from the shale to ultimately provide all process heat requirements.

The work of our researchers has proven the viability of gasification of pyrolyzed Eastern U.S. Oil Shale in a small unit. Up to 90% of the original sulfur has been removed, and as much as 20% of the starting carbon has been gasified at realistic temperatures and residence times. A final spent shale which contains almost no residual carbon and sulfur and should have no acid generating capacity has been produced. Thus, we have demonstrated that KENTORT II could completely recover the total energy potential of Eastern U.S. Oil Shale while producing a spent shale with enhanced environmental safety.

By the end of the current program in FY 1989, the research program for KENTORT II will have successfully proven many aspects of the process. A larger system is essential if development of the process is to continue. A completely realistic simulation of commercial-scale conditions is necessary

using a larger system. With a six-inch reactor, 80% of the heat for the pyrolysis zone would be provided by recirculating char, and heat losses would be less severe. Scale-up would also enable evaluation of commercial materials of construction, and sufficient crude oil and spent shale would be produced for upgrading studies and environmental research. Also, oil shales from other eastern states could be tested.

The proposed research for FY 1990 is the most cost effective plan possible consistent with a reasonable development rate and meeting the necessary technical criteria; $375,000 is requested for this effort. We will add a large increment of support from the Center for Applied Energy Laboratory at the University of Kentucky.

New Eastern Oil Shale technologies, such as KENTORT II, will produce spent shales which are physically and chemically different from those of the past. In our opinion, the time to conduct research in this area is now, simultaneous with process development, when environmental solutions can be integrated into process design. For the past five years, our researchers have been studying the environmental characteristics of retorted Eastern Oil Shale produced from a conventional technology originally designed for Western U.S. Oil Shale. We focused on the geotechnical, leaching, and reclamation characteristics of the spent shale and used a field research station in Montgomery County, Kentucky for the work. The field station has large concrete holding tanks (lysimeters) where the elemental release or leaching characteristics of the materials is being determined.

Thus far, our researchers have found that the shale materials are capable of forming acidic drainage and could release environmentally sensitive elements. This has pointed out the need to further reduce the sulfur content of retorted Eastern Oil Shale to eliminate these hazards. Sulfur recovery was one of the key considerations in the development of the KENTORT II gasification stage. We also found that small laboratory tests cannot predict the behavior of materials under actual field conditions.

It is important that studies be initiated on the disposal of spent shale having the characteristics of that from advanced technologies. The fully instrumented field research site operated by our Energy Laboratory will be used to study retorted Eastern Oil Shale mined in southern Indiana. Large quantities of this shale was retorted under U.S. DoE sponsorship in a pilot plant and will undergo further processing by fluidized bed combustion. This material will be similar in nature to that produced from an advanced eastern oil shale process like KENTORT II and will be available in sufficient quantity for meaningful research.

The materials will be installed in the field lysimeters in a configuration that will duplicate a disposal pile. The chemistry of the leachates, generated under completely natural conditions, will be determined over several seasons and the physical changes of the shale will be documented. In later years, additional lysimeter experiments can be conducted at the University of Wyoming indoor facility. This unique installation allows extreme weather conditions that cannot be expected in a short duration field study.

A Systems Management Model approach will be utilized in this work which will make the information useable for other systems. The field data along with hydrologic, mineralogic, soil characterization, and mine and retorting technology information will be integrated into this computerized model. Thus, the impact of chemical changes of the spent shale will be assessed as will variations in disposal practices and spent shale utilization options. The model and the fundamental data generated will have applicability in the management of other energy related solid wastes including that from coal utilization. We are requesting $355,000 to begin this research. Again, a large increment of support from the University of Kentucky Energy Laboratory will be added to this effort.

Eastern oil shale represents an enormous energy potential of national importance. However, it is not as well understood as coal or Western U.S. Oil Shale. To realize its full potential requires research. This research should be conducted now by making modest investments over a longer period of time to support a stable research program. We believe in this approach, and for Fiscal Year 1990, we support an $8.0 million program for Eastern Oil Shale research which includes:

- $4.5 million to continue the process development research at the Institute for Gas Technology.
- $2.0 million to continue novel process development research; included in this is $375,000 for continued support of the KENTORT II technology development program.
- $1.5 million for environmental studies for Eastern Oil Shale, including $355,000 for the initiation of spent oil shale disposal research.

I appreciate this opportunity to present my views and also for the previous support provided the Eastern Oil Shale program. Funding at this modest level will enable research to be continued at several research universities and laboratories across the Nation with the goal of exploiting and utilizing Eastern Oil Shale as a valuable source of liquid fuel.

Senator FORD. Thank you, Mr. Peters.

Let's go back to Mr. Disbrow a minute. Mr. Disbrow, DOE stated earlier—and you heard Secretary Wampler—that 22 of the 29 projects I believe selected thus far are retrofit technologies. He indicated that the administration is not supplying any incentives for their use since they are ready for commercial deployment.

Do you agree with that statement? I kind of read your statement you are not quite sure they have matured enough.

Mr. DISBROW. I am certainly not an authority in terms of each and every one of the technologies. But my impression from our technical staff is some may be, others will likely not be. Most of the retrofit technologies other than flue gas, the sulfurization systems, are fairly modest in scope and I would think that is one of the reasons why the vast number.

Senator FORD. When you say modest in scope, how large are you calling modest?

Mr. DISBROW. Well, $15 million, $20 million, something like that where the major technologies like pressurized fluidized bed, atmospheric and integrated gas combined cycle, you are talking hundreds of millions of dollars.

Senator FORD. Well, Mr. Peters is asking for about $700,000 for eastern shale and you are talking about $20 million being modest. Tell me why a university—and I think they do have a pretty good lab there to do work. It was one of the earlier ones and it has had a lot of experience and background. Their track record I think is reasonably good. But tell me why your $20 million is modest and their $700,000 is——

Mr. DISBROW. Well, the technology we are dealing with, $20 million is a modest number. It is like the B–2 bomber. If you are going to do that, it is going to cost you a half a billion dollars. You can't do it for $700,000. The hardware costs are enormous.

I do not contend that that is not a very important project that the University of Kentucky wants to undertake, and if the funds are available, why not? It sounded worthwhile to me.

Senator FORD. Would you then go further and ask that there be incentives given to use these technologies for the acid rain legislation?

Mr. DISBROW. In terms of getting them deployed as rapidly as possible?

Senator FORD. Yes.

Mr. DISBROW. Yes, I would, and the reason for that is we are going to be on a very tight timetable. I am not even sure it is achievable looking at the year 2003.

Senator FORD. The year 2000 plus a three year forgiveness if you sign up for clean coal technology. Is that what you are talking about?

Mr. DISBROW. That's right. There are still going to be a lot of risks.

Senator FORD. So, you have to make a decision before the year 2000 then.

Mr. DISBROW. Well, let's take my own company's project. We are building a pressurized fluidized bed demonstration project, a commercial operation or initial operation in October 1990. And we will

need at least a year and a half to two years of experience with that project.

Senator FORD. Is that similar to the operation at Shawnee in west Kentucky?

Mr. DISBROW. Yes, similar, but Shawnee I believe is a smaller scale.

Senator FORD. Go ahead. I'm sorry.

Mr. DISBROW. The next project, if we upscale it, we would be on a fast track to get it done by mid-1996. Now, if again we need a year to 18 months of experiment and feedback to ensure that we haven't made any major errors, so that we can then go forward with the next series, the third attempt will just about miss 2003. And there is going to be a very large risk in doing it by the year 2003, but there will not be wide scale deployment in my opinion of pressurized fluidized bed by 2003. The risks are simply too high.

So, we do need incentives because if you get an incentive, you are willing to take a bit more risk. And, of course, that's the tradeoff with the retail rate regulator as well because one must remember in the utility business in the final analysis, whether we survive or don't, it's a function of the viewpoint of rate regulators on the prudency of our actions.

Senator FORD. Well, would you be willing to limit the list of technologies for incentives to the ones that the administration apparently have in their back and forth? The latest one we have seen——

Mr. DISBROW. Well, I have seen a plethora of lists.

Senator FORD. But basically we have five or six. Yes, any listing to the exclusion of other technologies.

Mr. DISBROW. I see no reason to exclude any technologies, sir. Why be selective?

Senator FORD. Well, we are looking at the time frame. So, if you are going to nickel and dime all these——

Mr. DISBROW. I think the technologies that were named in the list which I think I saw—I think I saw the list that you have seen—they are the major technologies. They are going to be the last to be developed. So, yes, I think they do need an extra push. Some of the more modest technologies may come in a bit earlier.

And I refer you to the attachment to my prepared remarks which indicates the various technology time frames for development and commercial deployment.

Senator FORD. What bothers me, Mr. Disbrow—and I apologize for taking too long here maybe—we are going to be pushed I think to make a decision on acid rain legislation. The time frame has slipped some. It has already slipped 30 days and we are still seeing back and forth and that sort of thing.

But when we make that decision and we look at the year 2000—say, we take 1995 and 2000. I am not for 2000 by the way. I want 2003 and then maybe the forgiveness period of three if you have signed on. That would be my judgment. But, nevertheless, we are going to have to make some kind of a judgment and put it in. How do we adjust to some new technology that may come on that is very favorable when we know the list that you have seen and I have seen, that's about it out there now that would be available by the year 2000?

Mr. DISBROW. I would not think if we were to embark on a whole new technological concept today, that we would have any chance of having that developed to commercial acceptability by the year 2003 or 2005. Generally generation technology takes about 20 to 25 years from laboratory to commercial operation. And all of our history has been that, and I think clean coal is going to follow a similar pattern before you get really wide scale market penetration.

Senator FORD. The process, fluidized bed combustion operation, has been operating at 105 percent with 160 megawatts. They found a few bugs, but they have been able to keep it up at 105 percent, which is pretty good I think for the short period of time it has been in operation. It does give some hope that we might be ready for something like that.

Mr. DISBROW. Well, if we want to stay with that scale and that particular design, that is perhaps true. Up-scaling in terms of size and so on is a great risk in our business.

Senator FORD. Well, I understand that, but we are moving. That is 160 megawatts. That is not very large, but that is one of the larger ones out there I think.

Mr. DISBROW. That is a little further along than circulating or pressurized fluidized bed.

Senator FORD. You have been concerned about the dates of 1995 and 2000. Do you have dates that you would recommend?

Mr. DISBROW. Well, any extension—you know, two years in each time frame will give us additional opportunity. I can't guarantee you that by 2005 all will be well with clean coal technology. But we have a better opportunity to be there with the additional two years.

Senator FORD. In your testimony you have a range of estimated commercial availability of dates of clean coal technology.

Mr. DISBROW. That's correct.

Senator FORD. Would you basically stand behind those dates?

Mr. DISBROW. They are the best technical information I can lay my hands on, sir. So, I would have to accept it——

Senator FORD. Most of them are 2005 and beyond.

Mr. DISBROW. That's right. That is for wide scale deployment now.

Senator FORD. What does "confident commercial use" mean that you have used in your statement?

Mr. DISBROW. That is not my phrase.

Senator FORD. Well, you used and you presented it here. And so, I will ask you to try to tell me what the hell it means.

Mr. DISBROW. I would say warrantable and merchantable. If you install it, you have relatively high assurance it will work and perform well.

Senator FORD. Pete, I am not in too much of a hurry. Do you have some questions? I will just back off here for a minute.

Senator DOMENICI. Could I ask just a couple?

Senator FORD. Go ahead, yes.

Senator DOMENICI. Mr. Disbrow, let me ask you were you telling us in a general way that while we may be moving ahead with the funding, that we better pay some attention to both the incentive side and to the regulatory side?

Mr. DISBROW. Yes, sir.

Senator DOMENICI. The WEBCO kind of decision would be devastating to the clean coal technology approach if we do not get that in some way fixed. Is that not correct?

Mr. DISBROW. That is correct, sir.

Senator DOMENICI. Are there other regulatory recommendations in that so-called commission report that have not been acted upon that are significant in your opinion?

Mr. DISBROW. Well, I think, yes, there are several, one of which is the need to expedite environmental permitting for clean coal technology.

Senator DOMENICI. When you speak of incentives, it just dawns on me that we have a national research and development tax credit. Does that apply to a utility that has made this kind of investment?

Mr. DISBROW. I cannot answer that, but I will check and respond.

Senator DOMENICI. It would seem to me that if it does, then something like that ought to be included. I do not think we would be wanting the equity owners to pay at all, nor would we want the rate users to pay it if it is, indeed, research that may fail that we have encouraged. It seems like rather than invent a whole new incentive—we are going to be talking about the research and development tax credit—we ought to maybe take a look and see if it doesn't apply here or make it more specific. Would that not be helpful?

Mr. DISBROW. Yes, it would, but we are beyond the pure research by this point in time. We are now in the practical application of the technology. So, whether it would be applicable to R&D, I am not sure.

Senator DOMENICI. Well, it seems to me that it may not, but that does not mean that it should not.

Let me ask one other question. Within your company's framework, do you have ongoing scientific researchers of the type Dr. Squires is talking about or do we have here the chemical and engineering research capability of this country off on the side and, as in many industries, not vested within the operation of the companies?

Mr. DISBROW. We have an environmental engineering group which follows all aspects of environmental requirements. Now, they are pure scientists. We have one or two. Most of them are engineering people that watch the science and try to apply the scientific knowledge to our particular circumstance.

Senator DOMENICI. Dr. Squires, you have recommended something that has been part of a discussion on this subcommittee for a number of years. We can't seem to get there, but some of the national laboratories, a consortia of them, Los Alamos, Livermore, Oak Ridge, have for a long time been recommending that this country establish some more concerted focus on basic coal science. Do I read you right that you are talking about that, or are you talking about something one step removed from that as you recommend this basic coal research?

Dr. SQUIRES. I am speaking of basic coal science of the type that, for example, Dan Hartley at Sandia National Laboratory is advocating.

Senator DOMENICI. And would it be fair to say that with the modern breakthroughs that have been occurring in engineering and in modeling and in simulation and in basic physics, that we may, indeed, need some additional research even while we are going on with applications?

Dr. SQUIRES. I think we need additional research and deployment. The modeling has come along to the extent where I think that we can successfully model some of these systems and save ourselves some dollars and some years.

Senator DOMENICI. Let me tell you, as a member of the professional association in this country, one of the problems that you have that we have. If we were to talk up here about—let's just pick a number—a $5 million program to muster the resources within two or three national laboratories to do basic coal research, the antennas go up immediately that we are talking about taking away something that Bartlesville does or something that is going on at laboratories of West Virginia today.

I wonder if you might, even if it is for me personally—if the Chairman wants it, you can put it in the committee record—academically try to distinguish in five or six paragraphs the kind of research you are talking about from the kind of research that we know is going on in the great coal laboratories in West Virginia, Kentucky, at Bartlesville in Oklahoma and the like because I see there no conflict. I do not think one is robbing from the other. I think quite to the contrary. One is not being done and the other is. One is much different than the other. Could you do that in some kind of a professional manner on a page of paper that we might look at?

Dr. SQUIRES. I would be happy to, Senator.

Senator DOMENICI. I would appreciate that.

Senator FORD. If you will submit that to the committee for the record, Senator, I would appreciate having it in the record. So, if you will send it directly to us, we will put it in record.

Senator DOMENICI. I appreciate it.

[The information follows:]

Associated
Western
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Incorporated

August 23, 1989

The Honorable Pete V. Domenici
Ranking Minority Member
Subcommittee on Energy Research
and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Senator Domenici:

At the Subcommittee's hearing on Fossil Energy R&D and the Clean Coal Technology Program held on July 11, 1989, you posed a question to me. I am pleased to provide you with the following response.

The United States still has an advantage over other nations in its scientific and technological resources. Current fiscal constraints demand that we use existing resources to meet scientific challenges and gain technological advantages wherever possible. One of the challenges that could provide a significant advantage to the nation is more extensive utilization of coal, our most abundant national resource.

In order to meet such an objective, there are three imperatives. We must gain a more fundamental understanding of the chemical and physical nature of coal. We must develop coal utilization technologies which exploit the scientific knowledge derived from such basic studies. We must involve the various components of our scientific and technological establishments in the tasks that they are most qualified to undertake.

Frankly, I am quite aware that implementation of the latter imperative requires political sensitivity. However in my professional opinion, I see no scientific or engineering conflict in its implementation. Technology is concerned with the application of knowledge to achieve practical objectives. The DOE Energy Technology Centers (ETC's) have played and continue to play a vital role in transforming the knowledge derived from basic research into coal utilization processes.

However, because of the ETC's focus on the technological aspects of the coal utilization challenge, these centers are not as well qualified to investigate the fundamental nature of coal. Basic research of this type is more appropriately conducted by university and national laboratory researchers. Research efforts at these institutions are predominately directed toward developing fundamental knowledge of the type needed by the ETC's and private industry to develop coal utilization processes.

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It is essential that we balance our basic and applied research activities. To accomplish this, I reiterate two recommendations, one included in my previous testimony and the other submitted to this subcommittee in a January 30, 1989 letter from Dr. Clayton F. Callis, President of the American Chemical Society.

- o Double the level of funding for basic research in Advanced Coal Research Programs and maintain this level of support for at least five years.

- o Award research funds on the basis of peer review of submitted proposals and continuing programs.

I hope I have made it quite clear that both basic research in coal science, conducted primarily at universities and national laboratories, and applied research in coal utilization, conducted primarily by ETC's and private industry, are essential. To paraphrase your analysis of the current situation, the problem is that the latter is being done without enough of the former.

I trust that I have been responsive to your question. Thank you for the opportunity to testify before the subcommittee on behalf of the Fuel Chemistry Division of the American Chemical Society and for the consideration that you and your colleagues have given to this vital issue. Please contact me if I can provide additional information.

Sincerely,

Thomas G. Squires

Thomas G. Squires
Executive Director

cc: The Honorable Wendell H. Ford, Chairman

TGS:clm

bcc: Ms. Teri Curtin

Senator DOMENICI. Mr. Webb, with reference to some of the things you have been talking about in your comments here, I am familiar with secondary and tertiary recovery potential for crude oil in the United States. And I remain convinced that it is the biggest opportunity being missed by the United States right now, that if we want to put something in place that is the most efficient recoupment of oil for the United States, it would be a secondary and tertiary tax credit of some type. I think the cost would be very minimal and we would get that oil out of the ground. We already know it is there.

Is there something similar in natural gas? You used those kind of words, but I was not aware that we are leaving substantial quantities of natural gas under ground in the ordinary drilling of natural gas.

Mr. WEBB. Senator, we have funded some recent studies with some of the state geological groups, and the Bureau of Economic Geology at Texas is estimating some of the older fields in Texas that they think perhaps you are only recovering about 60 percent of the gas in place. The reason being is twofold. One was a lot of these fields were drilled back in the 1940s and 1950s when, number one, our sophistication and instrumentation was a lot less than it is today. And secondly, gas was regulated at about 15 cents. So, a lot of reservoirs and horizons were probably passed deliberately because you went to the big, deep, thick sands.

It appears to us that if we are successful in working with them in this consortium we have put together in developing some of these modeling theories and prove it in practice, you might get another 20 or 25 percent recovery. You don't have to pay that 50 percent front end for the exploration work because the field is there, and the transmission lines are there, and the processing plants are there.

Senator DOMENICI. I wonder if you have within the institute the capability of looking at the current pending tertiary recovery tax credit bill—we can forward it to you—and seeing if some amendments to it might be in order which would sensitize the natural gas industry to that recovery also. It would not now be included because none of us had in mind that it was a question of a tax incentive.

Is it an incentive or is it technology at this point?

Mr. WEBB. Well, I think really at this point it is probably a combination of the two. The technology is we need to learn how to log through casing, go back into old wells and log through casing and do it accurately, and then secondly is being able to seismically identify bypassed reservoirs. But some kind of an incentive would certainly make—you do not have to look for it, but you have to spend more money to produce it because, obviously, is not the thick sands.

Senator DOMENICI. Thank you.

My last question is to you, Dr. Peters. When you speak of continuing research in Devonian shale in the east—one of the reasons—not the single one, but one of the reasons shale evolution in the United States did not proceed beyond its current state is a market situation. When the price of crude oil dropped precipitously and is no longer contemplated to go up to $40, $50 a barrel in 15

years—it might, but it isn't contemplated—we lost enthusiasm for alternatives that we knew the value was far in excess of the market or short-term predictable market.

Is there something about Devonian shale that indicates that we should proceed, nonetheless? Or is this just in anticipation of a market *x* years down the line when crude oil or its equivalent is much higher?

Mr. PETERS. I think our best estimates at this point in time based on the status of our technology—and that is one of the reasons we want to do additional scale-up—are that it would be about $35 a barrel. Now, one of the things that we also want to do is develop a process that we can feel confident in being environmentally acceptable at this point in time. That is critical. We do not want to get into the position where we have to retrofit the process because of some unforeseen environmental concerns later on. We want to modify the process as we go along. But at this point in time, our best estimates are that the cost per barrel is about $35.

Senator DOMENICI. But you would be in a position, hopefully, if you could continue your research, to say even if it is $35, at some point in time you might want it at that price. But in the meantime, we will try to rid the evolution of this product of its environmental degradation which has been a big hangup in the past. Is that what you are saying?

Mr. PETERS. Well, in actuality, during the last decade, we have been able to ratchet the cost per barrel down considerably, and we feel with additional technology development, that we will see some additional ratcheting down. We do not believe we are going to get to the state of a $20 per barrel oil shale. But in any event, the process modifications that we can make at this particular early stage are much better than when you are at a very large scale-up in trying to do the analysis.

Senator DOMENICI. Thank you very much, Mr. Chairman.

Senator FORD. Thank you, Senator Domenici. You asked a good many questions here that probably saved me from asking them too.

Mr. Disbrow, let me ask you one other question. You had the list of the technologies and when they would be available. Yet, in your statement on page 6, the last line said "freedom of choice in the expanded time frame of perhaps two years might accommodate the phase one objectives." That is 2.5 I guess you are referring to.

Mr. DISBROW. Yes, sir.

Senator FORD. "While keeping clean coal alive." And on page 8, you said, "An additional point with respect to any extension beyond the year 2000, it should not be restricted to retrofit or repowering. It should be available where replacement of a new plant is the economic choice over retrofitting or repowering. Surely that would best serve the consumers' interest." Are you saying that the utility would build a new plant——

Mr. DISBROW. Yes.

Senator FORD [continuing]. Rather than retrofitting or repowering?

Mr. DISBROW. If we were to explore retrofitting or repowering of an existing plant, and the economic comparison indicated on a life cycle cost you would be wiser to go out and build an entirely new

facility than repower, I think we should have that option because that serves the consumers' interest.

Senator FORD. If you decide to build a new plant, how much time do you think you would have to have on an average, ball park?

Mr. DISBROW. I would not think it would be proportionally much longer than a repowering.

Senator FORD. Than three years?

Mr. DISBROW. A lot will depend on the permitting aspects because that is one of the longest periods in new power plant construction or even repowering at this point.

The point I made at the 1995 issue is this. If we are forced to construct flue-gas scrubbers on named power plants in a very protracted timeframe, our entire financial energies are going to go into doing precisely that. There will be no funds available for clean coal. If we have a more relaxed timetable and we have freedom of choice, we may be able to see our way clear to maintain funding of clean coal and meet the phase one objectives.

Senator FORD. Of course, those that are pushing so hard for acid rain legislation or clean air legislation are going to say that is just the utility's way of trying to delay.

Mr. DISBROW. We cannot remake the economic climate of the world, sir.

Senator FORD. I am just laying out there what we get on the other side.

Mr. DISBROW. I have discussed it on numerous occasions with the folks that have a contrary mind.

Senator FORD. Mr. Webb, on page 16 of your larger statement, you talk about gas-related research and you were discussing that with Senator Domenici—your Texas Bureau of Economic Geology. This is DOE's testimony. I'm sorry.

But the Department is also proposing funding to conduct high priority gas-related research. It says that "A DOE sponsored"—and I think this ties in to what you and Senator Domenici were talking about—"study last year conducted by a panel of gas experts identified enough natural gas in the lower 48 to meet current demand for 35 years"—that is current demand for 35 years—"at costs below $3 per thousand cubic feet. Of the nearly 600 trillion cubic feet of gas estimated by the panel to be in the cost range, nearly 60 trillion cubic feet was included in the secondary gas category, that is, gas in bypass reservoirs in untapped compartments or in deep pools that could have been missed by conventional production methods," so forth.

Now, Mr. Disbrow, I understand you have to catch a plane.

Mr. DISBROW. Sir, pardon my rudeness, but I have to give a talk tonight.

Senator FORD. You are not rude. Get the hell out of here. [Laughter.]

Do you have to go too?

Dr. SQUIRES. I have to catch a plane.

Senator FORD. Goodbye. You all chase each other.

Do you have to run?

Mr. WEBB. No, sir.

Senator FORD. What about you?

Mr. PETERS. I'm fine.

Senator FORD. Good.

Let's get back to this statement then by DOE. Can you do that for under $3?

Mr. WEBB. We think there is a good chance we can, Senator. That is the same work that we are talking about, secondary gas recovery.

The reason being is that our studies would indicate that in frontier areas where you are looking for gas, about 60 percent of the cost is in the exploration to try to identify the gas resource. That has already been done here. So, what we need to do is develop—and we do have ongoing with DOE a cooperative R&D venture in this area where we have the Bureau of Economic Geology at Texas, us, and DOE and about eight producers involved in this joint program. We think that is a realistic target, a wellhead price of $3 to recover some of this bypassed gas in existing fields. Yes, sir.

Senator FORD. Two things bothered me. One is that I believe back in early spring they had some trouble getting all the natural gas needed during a severe cold spell. It reminded me of the mid-1970s. And I understood that they had plenty of gas, but the distribution system couldn't accommodate the requirement on the other end. Do you recall any of that?

Mr. WEBB. Senator Ford, yes, sir. I think what they are talking about is I believe there was a bottleneck in trying to get gas out of Texas and Oklahoma and Louisiana to California where they had to have a few curtailments this past winter for some fuel-switchable customers. And the problem is I think there are only two main pipelines that go from that part if the country into California. It wasn't the fact that there was not gas that could be produced. They just could not get it to the market that had the biggest demand.

Senator FORD. I was under the impression it was more like in the midwest, south midwest, southern midwest, Texas, in that area. I am just recalling some publicity which reminded me of section 433, or whatever it was, of the Natural Gas Policy Act where you could buy your own gas and have a well. And you would have to transport it and have butane tanks and everything trying to make things work. And

I remember that with some sort of cringe. I was around during the depression also, and so I worry maybe more than my children worry or my grandchildren will.

But there is not a vessel being constructed now that will use coal. Are we getting ourselves in the position where we are going to be so dependent on natural gas that we will not able to—if we get into a shortfall or we get into a problem of distribution or we do not have the pipeline to distribute the gas, are we going to get into the same kind of trouble that we were back, say, 15 years ago?

Mr. WEBB. Senator, that is a possibility that I don't think is very probable because I assume these people that are buying these gas turbines for the utility executives are entering into long-term gas contracts with producers.

Senator FORD. Well, now, you can't get a long-term gas contract I don't think. Isn't it more difficult to get a long-term gas contract?

Mr. WEBB. It is more difficult because to sign a long-term gas contract, the producer is not willing to sign a contract at today's spot market prices But they are being signed, contracts for 15- and

20-year supply. It just they are not the old contracts with an absolute fixed price forever. So, there is a greater risk from the standpoint of the price of gas going up.

Senator FORD. Are we going to have another take and pay problem?

Mr. WEBB. No, sir, that wouldn't create a take or pay problem. That type of contract wouldn't. And I do not think any producers or pipelines or LDCs for that matter are signing these old type of contracts where if you couldn't use the, gas you had to pay for it.

Senator FORD. But you understand my being nervous about this. Not that I am trying to cast any aspersions on the gas industry, but I was here when we tried to move gas around. Your whole testimony was displacing oil, wasn't it?

Mr. WEBB. Yes. Yes, it is. We think that really gas' role in electric generation other than initially there are going to be some power plants built using gas turbines that, as these new coal technologies come on, are going to be phased into either intermediate or peaking systems, which is probably the best use for those.

But the real role for gas is in old power plants that are 15 to 20 years old, see if we can't use 10 or 15 percent gas with the current local coal to reduce emissions enough to meet these new compliance standards and not have to make a choice of do I put a scrubber on a 25-year-old plant that only has a 10 year life left, or do I shut that plant down. There ought to be a third option.

Senator FORD. Well, they are going to shut the plant down if you have to put a scrubber on it.

Mr. WEBB. Yes. And we say there ought to be a third option which is let's look at using 10 or 15 percent gas with that system to allow you to continue to use their local high sulfur coal, Senator.

Senator FORD. Well, I do not want to get into the position where we—I was governor when we were trying to alternate the fuel. We were shutting down the penitentiary, switching from oil to gas and getting all kinds of problems, and school systems were having problems. And we were trying to allocate. We were lucky that we had a pipeline in our state. One of major industries was able to help us accommodate some of those problems. We were not nearly as bad off as, say, Ohio was in those days. Ohio was in real trouble during that era.

Mr. WEBB. Well, it would seem to me it would just make good policy that you try to adopt fuel-switchable, if you would, large systems, okay, the large combustion systems because there——

Senator FORD. Well, you can't switch a gas turbine to coal, can you?

Mr. WEBB. No, but I think most gas turbines now are being bought with the intent of going to integrated coal gasification and that technology, which several of the clean coal projects are looking at that. So, it should start off with gas, and as you get further down the road, you would use coal gasification. I believe that is what EPRI has also been developing for the last eight or ten years at that site out in California.

Senator FORD. I don't think EPRI has anything going right now burning coal, do they?

Mr. WEBB. Maybe not. They were running that plant at Cool Water for several years which is taking coal gasification——

Senator FORD. It has been shut down. I think it has been terminated.

Mr. WEBB. Okay.

Senator FORD. You know, the only coal burned in California was that experimental operation, and they have more air pollution problems than most other parts of the country.

Mr. WEBB. I understand that, but they weren't caused by that plant.

Senator FORD. Absolutely.

Mr. WEBB. I think that plant is extremely clean.

Senator FORD. I understand that.

Finally, Mr. Peters, aren't you going to have a symposium on eastern oil shale mid-November or something like that?

Mr. PETERS. That's correct, yes.

Senator FORD. What do you expect to have at that time, what kind of support and what kind of knowledge will you be able to spread around as a result of that symposium?

Mr. PETERS. That symposium is one that occurs every year, and we have been very fortunate to have researchers from all around the world and across the United States looking at eastern oil shale technology in particular and even some of the tar sands work. So, it really brings science and engineering research from worldwide to address some of the issues. It gives us an opportunity to compare where we stand in eastern oil shale research with some of the shale research going on in other types of shale.

Senator FORD. All right. I don't believe I have any other questions. You gentlemen were mighty patient and I thank you for staying around with me. We had a good crowd, didn't we, when we started. And Senators leave and witnesses leave, and the administration people left earlier. But we do thank you.

And this hearing is adjourned after I say that Senator Gore has a statement for the record on cuts in the MHD program, and that will placed in the record, following my opening statement.

Thank you all very, very much, and this hearing is adjourned.

[Whereupon, at 4:49 p.m., the hearing was adjourned.]

APPENDIXES

APPENDIX I

Responses to Additional Questions

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

JULY 11, 1989, HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

UNITED STATES SENATE

WITNESS: J. ALLEN WAMPLER

ASSISTANT SECRETARY FOR FOSSIL ENERGY

U.S. DEPARTMENT OF ENERGY

QUESTIONS FROM SENATOR FORD

Question 1: **Mr. Disbrow, in his written testimony, expresses concern about EPA's so-called "WEPCo decision." He expresses fear that if the WEPCo decision were to be applied broadly, a powerplant may be required to impose stricter emissions limits than if the plant owner had not undertaken a clean coal project. This is true even if the clean coal project is demonstrated only for a limited period of time. This seems to me to be a strong motive not to participate in the clean coal program or use any new technology because of the risks associated with its use.**

- **Do you believe that these fears are well-founded?**
- **If so, is DOE taking any action to help this situation?**

Answer: The fear that the "WEPCo decision" may provide a strong motive not to participate in the Clean Coal Program is well-founded. A number of the Participants with active projects under Clean Coal Technology I, and those selected and undergoing negotiations in Clean Coal Technology II have expressed strong reservations about continuing without some relief from the ruling made on WEPCo. This ruling was a contributory factor in the M.W. Kellogg Co. not being able to find a host site and subsequently withdrawing their project from the Program.

DOE has from the outset worked aggressively with EPA and the Participants to find a solution to this problem. An interim measure was taken whereby EPA agreed to provide "research related no-action assurances" on a case by case basis to clean coal technology projects. After some interaction with the Participants and consequent clarifications, some Participants

Answer 1
continued: were satisfied. However, others feared that they remained in jeopardy because the "no-action assurance" stipulates formally that they have done those things which trigger a Prevention of Significant Deterioration (PSD) Applicability Review even though EPA, in a highly qualified manner, agrees not to take action. This leaves the participant subject to civil suit and does not provide a real guarantee that EPA might not come back and initiate a PSD Applicability Review for any number of reasons.

DOE sought a Program-level waiver of the New Source Performance Standards and new source review for Clean Coal Technology projects funded under the CCT Program and CCTs used to comply with Clean Air Act requirements. Title V of the President's Clean Air Act bill does afford relief for projects funded under the CCT Program in regard to waiving PSD Applicability Reviews, and it is hoped that this position will prevail for ongoing CCT projects.

We continue to encourage EPA to issue policy guidance consistent with the President's Clean Air Act bill and to give assurance to CCT Participants that they will not be penalized for participating in the Program.

QUESTIONS FROM SENATOR FORD

Question 2: Mr. Wampler, in your view, is the clean coal program limited to one-of-a-kind demonstrations of technology?

Are there benefits to replication of a technology so that we can move further up the learning curve and lessen the risks of deployment?

Answer: The current guidance from Congress would appear to give the Department sufficient flexibility to replicate technologies if it were deemed necessary to establish a data base sufficient to prove economic competitiveness. Once proven, it is assumed that market forces would take over and the Government role would be to encourage deployment.

To develop a data base requisite to instilling the confidence of achieving cost competitive commercial application, it is frequently prudent to conduct complementary demonstrations of the same basic design in the capital-intensive technologies in order to address a range of fuels, suppliers and operating variables.

To restrict future rounds to replication would be to unnecessarily restrict competition to only those specific technologies that have undergone or are undergoing demonstration at the time of solicitation. However, this issue is currently under review in DOE.

QUESTIONS FROM SENATOR HEFLIN

Question 1: **What is the status of the DOE's Clean Coal Technology Program? How many of the projects selected in the first round of solicitations have completed their negotiations with the DOE? How many of the projects selected in Round I are under construction, and when will they be operational?**

Answer: Under Clean Coal Technology (CCT) I there are eight active projects. Of these five are in construction or operation and three in the design phase as outlined below:

- Coal Tech - Advanced Combustor - Operation
- Colorado-Ute - Circulating Fluidized Bed - Operation
- Babcock & Wilcox - LIMB - Operation
- American Electric Power - Pressurized Fluidized Bed - Construction
- Energy & Environmental Research - Gas Reburn/Sorbent Injection - Construction (as of August 15, 1989)
- TRW - Advanced Combustor - Design (with operation of a pilot plant)
- Ohio Ontario Clean Fuels - Coal/Oil Coprocessing - Design (with operation of a process development unit)
- Energy International, Inc. - Underground Coal Gasification - Design

With the termination of the M.W. Kellogg Integrated Gasification Combined Cycle (IGCC) Project after preliminary design, the City of Tallahassee Circulating Fluidized Bed Project was selected for negotiation from the alternative projects list (last active project) in June, 1989. Three coal beneficiation projects

Answer 1
continued: selected off the alternative projects list in December 1988 and an IGCC project selected earlier remain in fact finding/negotiation. They are as follows along with the projected date for completion of negotiations:

- Western Energy Company - October 1989
- Combustion Engineering - December 1989
- United Coal Company - March 1990
- Foster Wheeler (IGCC) - August 1989

Under CCT II, negotiations on 11 of the 16 projects are expected to be completed by the end of September. Negotiations on all but two of the remaining 5 of the 16 projects are expected to be completed by the end of the calendar year. Only two of the projects -- Otisca and CE-Sorbent Injection -- are experiencing major problems in structuring the projects. Slippages have occurred on pre-award milestone schedules for 13 of the 16 projects, but only three of the slippages are major. For 10 of the 16 projects, the slippages range from one to three months. These are largely due to unanticipated time requirements on the part of the Participants in developing information requisite to negotiations (e.g. delays in receiving vendor data, pulling various agreements together, and working out patent and data rights).

QUESTIONS FROM SENATOR HEFLIN

Question 2: According to the Annual Report to Congress on the Clean Coal Technology Demonstration Program dated February of this year, it states that "These technologies will reduce and/or eliminate the economic and environmental impediments that limit the full consideration of coal as a future energy resource."

What are the environmental and economic benefits of these innovative technologies compared to the conventional emissions control technologies?

What are the projected annual SOx and NOx emissions rates of these technologies?

What are the efficiency levels of these technologies compared to the conventional technologies?

Answer: The purpose of a demonstration program is to demonstrate the technical, environmental, and economic performance of a new technology at a sufficient scale and number of operating hours such that impediments leading to commercialization and private sector acceptance are eliminated. These impediments cannot be resolved with small-scale, prototype research projects without integrated subsystems. The following table shows the expected technical, environmental, and economic benefits of emerging clean coal technologies compared to conventional coal technology:

Retrofit and Repowering Technologies	Capital Cost $/KW	Plant Efficiency	Emissions Reduction NOx	Emissions Reduction SOx
REPOWERING				
Conventional Plant w/o Flue Gas Desulfurization (reference)	1400	36%	-	-

Answer 2
continued:

Atmospheric Fluidized-Bed Pressurized	1200-1400	36%	50-60%	90%
Pressurized Fluidized-Bed	800-1100	40%	60%-80%	90-95%
Integrated Gasification Combined Cycle	1100-1300	42%	50-60%	90-95%
RETROFIT				
Conventional Flue Gas Desulfurization (reference)	200-300	33%	No Change	90%
Conventional Coal Cleaning	Increased Fuel Cost	36%	No Change	10-13%
Advanced Coal Cleaning	Increased Fuel Cost	36%	No Change	30-90%
Lime Injection Multiple Burner	80-110	35%	35-50%	60-70%
Gas Reburning and Sorbent Injection	50-110	35%	50-70%	60-75%
Advanced Flue Gas Desulfurization	175-190	33%	No Change	90-95%

QUESTIONS FROM SENATOR HEFLIN

Question 3: **The goal of the Clean Coal Technology Program is to make a number of these more efficient and environmentally responsive technologies available to the U.S. energy marketplace. When can the industrial and utility industries expect these technologies to be commercially available?**

Answer: We are confident that integrated gasification combined cycle (IGCC) technology will move forward this year. This translates to commercialization in the 2003-2005 timeframe. Pressurized fluidized bed combustion (PFBC) technology is moving ahead expeditiously and should be adequately demonstrated so as to be commercially available to the utility market in about the same timeframe as IGCC. (Although PFBC has essentially moved ahead of schedule, IGCC had somewhat of a head start with Coolwater and DOW.)

Atmospheric fluidized bed combustion technology is moving along well with a strong industrial data base and our planned CCT projects at utility scale (Colorado-Ute and Southwest Public Service). This technology should be ready for commercialization in the utility industry 1996-2000 timeframe.

The more advanced, sophisticated CCT retrofit technologies such as WSA-SNOX, Pure Air, SOx-NOx-ROx-Box, Selective Catalytic Reduction and Chiyoda should be commercially available in the 1997-2000 timeframe. The low cost retrofits such as sorbent injection, gas reburn, advanced low-NOx burners, and coal reburn should be commercially available in the 1994-1997 timeframe.

QUESTIONS FROM SENATOR WIRTH

Question 1: I wish to request Mr. Wampler to supply me with a complete briefing on the Department's program to provide research efforts directed specifically toward helping western coal, including funding levels for those programs.

Answer: Fossil Energy is sponsoring R&D activities related to Western Resources under the following programs:

o Coal Preparation

(a) Western Research Institute (FY 1989 - $341; FY 1990 - $632)
Research is being conducted on upgrading Western low-rank coals through drying and the effect this has on transportation costs. The drying technology being investigated is an inclined fluidized bed using CO_2 to inhibit oxidation developed at WRI.

(b) University of North Dakota Energy and Minerals Research Center (UNDEMRC) (FY 1989 - $564; FY 1990 - $352)
Research is being conducted on drying low-rank coals using a hot water drying technique developed at UNDEMRC. This project will be completed in FY 1989. In FY 1989, research activities will be initiated to investigate microbial desulfurization of Western coals.

o Flue Gas Cleanup

(a) UNDEMRC (FY 1989 - $422; FY 1990 - $0)
Two research activities are being conducted. One in R&D on catalyst-coated filters for the combined removal of NO_x and particulates from coal-fired boiler flue gas. Bench scale testing is scheduled to be completed by the end of FY 1989.

Answer 1
continued: The other area involves the evaluation of flue gas conditioning agents that result in particulate capture in baghouses. This project is scheduled to be completed in FY 1990.

o Waste Management

(a) UNDEMRC (FY 1989 - $125; FY 1990 - $0)

Studies cover the chemical characterization of low-rank coal wastes and the development of low permeability coal-waste liners for landfill cells.

(b) State of Wyoming (FY 1989 - $0; FY 1990 - $1,896)

A Memorandum of Understanding with the State provides for 50% DOE cost sharing to initiate studies of the wastes produced in the processing of Western coals. Included are chemical characterization and wastewater treatment studies.

o Alternative Fuels

(a) UNDEMRC (FY 1989 - $232; FY 1990 - $120)

The research activity involves the testing of both low-rank coal water slurries and dry ultrafine coal in combustion test rigs built at UNDEMRC. In addition, slurry rheology and additives will be investigated.

Answer 1
continued:

o Pressurized Fluidized Bed

(a) UNDEMRC (FY 1989 - $300; FY 1990 - $150)

The research effort involves the evaluation of low-rank coal effects on corrosion and erosion of heat exchange surfaces through long-term testing and extensive metallorgraphic analysis of exposed tubes.

o Atmospheric Fluidized Bed

(a) Western Research Institute (FY 1989 - $0; FY 1990 - $300)

This research effort to be initiated in FY 1990 will investigate the application of atmospheric fluidized bed (AFB) technology to western low-rank coals (LRC). Combustion tests of LRC will be conducted in a circulating fluidized bed combustion (FBC) or other concept.

(b) UNDEMRC (FY 1989 - $504; FY 1990 - $100)

Research efforts focus on the suitability of LRC and LRC slurries for use in AFB advanced concepts and special applications for the light industrial, commercial and residential markets.

Answer 1
continued: o Gas Stream Cleanup

UNDEMRC (FY 1989 - $250; FY 1990 - $0)
This research effort is expected to lead to development of a scientific and technical data base for fundamental low-rank coal reactions supporting advanced coal conversion systems.

o Coal Liquefaction

(a) UNDEMRC (FY 1989 - $400; FY 1990 - $0)
This work includes laboratory and bench scale studies on the use of low-rank (Western) coals in direct liquefaction processes.

(b) Direct Liquefaction Program (FY 1989 - $17,333; FY 1990 - $2,913) The Direct Liquefaction Program includes proof-of-concept (Wilsonville), bench scale, and laboratory scale research and development on improved processes. We estimate that 35 - 40 percent of this work utilizes Western coal resources.

o Heat Engines

(a) UNDEMRC (FY 1989 - $334; FY 1990 - $290)
Research is being conducted to burn Western low-rank coals in gas turbines and diesel engines.

Answer 1
continued: o Surface Coal Gasification - Systems for Coproducts Production

(a) Western Research Institute (FY 1989-$1,828; FY 1990-$1,117)
Research is being conducted to develop an advanced mild gasification process using an inclined fluidized bed gasifier concept to produce liquids, gases, and char which will be used in the production of carbon black and electrodes. Research is also being conducted to characterize mild gasification liquids for upgrading to marketable fuels.

(b) UNDEMRC - (FY 1989-$1,219; FY 1990-$1,138)
Research is being conducted to develop an advanced mild process using a spouted fluidized bed gasifier to produce liquids, gases, and char for the production of form coke, metallurgical coke pellets, activated carbon and electrode and form coke binders. Research is also being conducted for converting low-rank coals to low-cost hydrogen and advanced waste-water treatment techniques.

(c) TBD - (FY 1989-$0; FY 1990-$950)
Characterization and evaluation of advanced technologies for treating and upgrading low-rank coals in order to increase their marketability.

QUESTIONS FROM SENATOR WIRTH

Question 2: **It is nice to hear DOE talking about responding to global climate change problems. Is there a focal point for such activities in the Department, someone responsible for evaluating the degree of attention paid to this issue by various programs in DOE?**

Answer: Yes. The focal point for the Department of Energy's global climate change efforts is the Office of the Secretary. Ms. Linda Stuntz, the Deputy Under Secretary for Policy, Planning and Analysis has been designated to develop an overall DOE policy on the potential for global climate change, including the identification and development of potential response strategies.

With the Secretary's guidance, important roles are being played by six DOE offices:

- The Office of Policy, Planning and Analysis, as principal advisor to the Secretary on energy policy matters, acts as the Department central switchboard on global climate change policy issues and thereby helps assure a proper balance among potentially conflicting energy, economic, and environmental concerns.

Answer 2
continued:

- The Office of Energy Research conducts research to determine the quantitative links between the increasing concentrations of greenhouse gases in the atmosphere and climate change. The principal focus of the DOE research program is on the problem of early detection of the global warming signal as well as on the development of the capability to predict global and regional climate change.

- The Office of the Assistant Secretary for Fossil Energy conducts research and development aimed at improving energy end-use and conversion efficiencies and developing alternative energy options.

- The Office of the Assistant Secretary for Environment, Safety and Health is conducting several congressionally-mandated policy-related studies and provides the focus for the environmental aspects of global climate change issues.

Answer 2
continued:

- The Office of the Assistant Secretary for International Affairs is responsible for the various international aspects of the global climate change issue, including, representing DOE at International Conferences such as the Intergovernmental Panel on Climate Change (IPCC).

- The Office of Conservation and Renewable Energy conducts R&D aimed at improving energy end-use in transportation, buildings and industry, and pursues development of alternative energy options that would reduce future CO_2 emissions.

QUESTIONS FROM SENATOR WIRTH

Question 3: In my National Energy Policy Act, S.324, I proposed establishing an Office of Climate Protection in DOE to provide such a focal point? Do you think that this is a good idea?

Answer: Section 201 of the bill would establish an Office of Climate Protection reporting directly to the Deputy Secretary of Energy. We agree that this important area must receive the Department's attention at a high level. However, the legislative establishment of a specific office within the agency would materially detract from the flexibility provided to the Secretary by the Department of Energy Organization Act (P.L. 95-91) to adapt the organization structure to respond to changing needs and emphasis in the Nation's energy policy. We believe that decisions affecting the composition and management of DOE's programs should remain with the Secretary. As indicated in the answer to question two, the Secretary has established a capable organizational structure for coordinating the Department's actions in the global climate field.

QUESTIONS FROM SENATOR WIRTH

Question 4: In section 901 of my bill, I propose that DOE should evaluate the change in the production of CO2 that is likely to result from each project funded by the Clean Coal program, and from adoption of the technologies developed by those projects. Does the Department now do this? Wouldn't this be a good idea?

Answer: Yes, the Department does this now. Accordingly, we do not think this legislation is necessary. The Department has performed studies to evaluate the change in the production of CO2 that is likely to occur as a result of using CCTs versus the continued and increasing use of conventional coal technologies. First, each specific project is evaluated to determine what CO2 reduction might occur from that project. This is part of the Source Evaluation Board process. Secondly, the Department has completed a draft Programmatic Environmental Impact Statement which evaluates, among other parameters, the CO2 reductions which might occur from widespread deployment of the various technologies. This document has been made public and the material appears at Appendix B. The final Programmatic Environmental Impact Statement will be completed in December 1989. The Department is concerned about the generation of CO2 by the use of fossil fuels and its impact on the global climate. Since fuel utilization efficiency is a major indicator of CO2 generation, the third round CCT Program Opportunity Notice consequently gives added credit for more efficient processes.

QUESTIONS FROM SENATOR WIRTH

Question 5: The Department was sent this bill for comment several months ago. When will we have detailed comments on this proposal?

Answer: The Department recently provided extensive comments on the bill to OMB, which in turn, is circulating them to other agencies for their review. We will be happy to provide our final comments to you once the interagency review process has been completed.

APPENDIX II

Additional Material Submitted for the Record

STATEMENT BY BERNARD S. LEE
PRESIDENT, INSTITUTE OF GAS TECHNOLOGY
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
July 11, 1989

This year, the two most widely publicized and critical issues facing the energy industry are environmental: cleaning up nuclear waste and assessing the impacts of global air pollution. We may not yet know the magnitude of these problems, but we know their solutions will be costly.

This Subcommittee has a difficult challenge. While the problems of the nuclear industry and our resurgent reliance on imported oil remind us of the importance of our vast domestic supply of fossil fuels, the environmental warnings of acid rain and other air pollution problems help focus the task of finding ways to use fossil fuels more cleanly and efficiently.

At the same time that the needs and costs of energy research are growing, the days of a broad-brush approach are quickly passing. While the very nature of the federal role in research involves high costs, high risks and long lead times, the Congress is under increasing pressure to invest in sound ideas that will move us toward a cleaner, more stable energy supply at the lowest cost. The research community must help focus the search for sound future energy technologies.

We all must ask tougher questions. We need to carefully assess the real costs of new technologies and the levels of proof and certainty that end users of those technologies will require in the future. At the same time federal budget pressures are forcing stronger emphasis on private cost-sharing, investors are seeking higher levels of development and confidence before committing funds. Utility and industry executives may require stronger assurances and lower risks, demanding that the federal role in bringing technologies to "proof of concept" or "commercialization" be extended to more costly and complex levels.

IGT is proud of its work. As a private laboratory, we hope we add to the constructive diversity of ideas this Subcommittee must funnel into a comprehensive package of research. Our recommendations focus on improving the efficiency of developing technologies, lowering the costs of commercialization and addressing environmental concerns. We have involved private industry in planning and developing many of our projects, helping to ensure their commercial applicability.

Before discussing the IGT projects and recommendations in more detail, I would point out that IGT strongly supports the positions and recommendations of the gas industry. We agree that an Assistant Secretary for Natural Gas should be appointed, and that

the total federal gas research efforts should be funded at $125.8 million for FY90. Those recommendations present a very useful and workable research program to advance current technologies.

Within the gas industry recommendations, IGT specifically recommends the following:

FUEL CELLS:

IGT's IMHEX molten carbonate fuel cell (MCFC) design is one of three current approaches in an on-going DOE effort to develop a coal gas fueled molten carbonate system. The IMHEX concept's unique internal manifold offers design and cost advantages. IGT has made significant progress in developing the IMHEX system, and is ready to move to developing cost-effective scale up and testing long-term operation and performance of stacks. In order to keep advancing all three current, technologically distinct, MCFC projects,

IGT recommends $24.0 million to be evenly divided among the three existing MCFC contractors for development, scale up, manufacturing, endurance and large scale component testing.

In addition, there is a need for continued technology base research to provide testing and technical information useful to all three existing MCFC efforts. To support this needed base research,

IGT recommends $1.0 million to expand technology base research including the continuation of existing contracts for alternative anodes and corrosion prevention.

IGT has also begun work, under DOE contract, on a solid state proton conductor (SSPC) fuel cell, a novel, advanced fuel cell concept. Work on the SSPC will also provide valuable information on the potential uses of perovskites, a new class of ceramic materials. For this work,

IGT recommends $0.5 million to continue the evaluation and development of the Solid State Proton Conductor Fuel Cell.

COAL BED METHANE:

Significant amounts of natural gas were generated and trapped as our vast coal resources were formed. To recover that methane, greater study of the geoscience of coal beds is needed, developing greater knowledge of the retention of gas in various types of coal and the ability of trapped methane to move through coal seams at a rate that would support commercial production. To provide that base of knowledge,

IGT recommends $1.0 million for a joint geoscience research effort with IGT, the University of Alabama, and the West Virginia University, to determine the relationship among coal type, grade and rank, and geology and recoverable methane

from a wide range of coal beds to allow the maximum production of natural gas.

COAL:

In order to expand the clean use of our vast coal resources, a team headed by IGT is working under DOE contract to develop a mild gasification process to convert coal to marketable, value-added products. To determine economics and environmental and technical performance, and produce product for manufacturers to test, it is necessary to advance the IGT mild gasification process to the design, construction and operation of a 24 ton/day, mine-mouth process demonstration unit. To advance this work,

IGT recommends $0.4 million for the completion of the initial IGT mild gasification test program, and $3.0 million for initiating the design and procurement of long-lead items for a cost shared 24 ton/day PDU based on the IGT concept.

Development of cleaner, more efficient and more economical coal combustion systems is also essential for future coal use. IGT has invented an advanced, two-stage coal combustor capable of either atmospheric or pressurized operation, making it adaptable for retrofit or in new combined-cycle power plants. The first stage uses a fluidized bed to remove sulfur and limit NOx production, and the second stage, a cyclonic combustor, combusts remaining gases and separates solids to increase environmental performance and energy efficiency. To advance this work,

IGT recommends $1.0 million to develop an advanced two stage coal combustor based on IGT's sloping grid fluidized bed and cyclonic combustion technology, using existing PDU facilities.

EASTERN OIL SHALE:

With cost-effective production technology, Eastern oil shale could be a significant addition to our domestic energy supply. The necessary mining infrastructure and water resources are available for production, and the Eastern United States offers a close and ready market for liquid fuel products.

Retorting eastern oil shale in the presence of hydrogen has dramatically increased the yield of oil. A team led by IGT has been advancing this concept under DOE contract, developing a new technology known as pressurized fluidized-bed hydroretorting (PFH). The team is also developing technologies and processes to lower the cost of the PFH process, and is ready to test this process on a range of eastern oil shales. To continue this work,

IGT recommends $3.0 million for continued development of the PFH process, using a foil membrane in hydrogen production

and a carbon dioxide methane mixture in shale oil upgrading, and $1.5 million for design and engineering of a 4 ton/hour transportable PFH process development unit.

In the area of novel concepts, the KENTORT II system, an inert-gas, atmospheric-pressure fluidized-bed retort system being developed by the University of Kentucky Center for Applied Energy Research (CAER), has shown significant improvement in oil yields over conventional technologies. It also produces valuable chemical by-products and decreases environmental problems associated with spent shale disposal. Results so far from a 5 lb/hour integrated reactor system are very encouraging, but scale up is necessary to better simulate performance at a commercial level and to produce larger quantities of shale oil and spent shale for testing.

IGT recommends $2.0 million for continuing novel concepts research on Eastern Oil Shale including efforts to extend the data base for the KENTORT II process.

Assurances of environmental quality and safety are essential for implementing an oil shale industry, and the University of Kentucky CAER has been operating a field research station to study the environmental effects of retorted, spent oil shale. The application of a Systems Management Model to both field data and controlled laboratory conditions will allow careful assessment of spent shale disposal practices and utilization options.

IGT recommends $1.5 million to conduct environmental studies on Eastern Oil Shales which would include University of Kentucky efforts to assess mitigation of the impacts of retorted, spent shale.

BIOFUELS:

Conventional single-stage anaerobic digestion, used by many industries and municipalities as a solution to solid waste disposal, produces a product gas that is 60% methane and 40% carbon dioxide. Improving that gas to the 95% methane level needed for pipeline quality has been expensive. Application of pressure swing absorption techniques for gas purification can eliminate this costly step. Use of two stage anaerobic digestion instead of single stage will eliminate chemical costs and will allow the use of smaller and more economic equipment because of higher reaction rates. Integrating pressure swing absorption with two stage anaerobic digestion promises to be the most economic means of producing pipeline quality methane gas from solid waste or biomass.

IGT recommends $0.5 million to develop an integrated pressure-swing two-stage anaerobic digestion syster based on the GRI concept using an existing PRU to economically produce pipeline quality methane from solid waste and biomass.

Another alternative to solid waste disposal has been incineration. Some mass burn technologies have used refuse derived

fuel (RDF), removing non-combustibles from municipal waste to create a fuel that can be used alone as a fuel or as a supplement to coal in boilers. Use of RDF, however, has been hampered by unfavorable economics. IGT's RENUGAS process, a pressurized, fluidized-bed process for the gasification of biofuels, can be applied to RDF in a highly efficient, environmentally sound manner, eliminating the release of harmful emissions or the creation of dioxins while achieving power generation efficiencies up to 45%. The process can also be used to produce a synthetic gas to be converted to methanol. RENUGAS combined cycle power plants can also be economically built in a wider range of sizes than most mass burn facilities, making the technology available to a broader range of users.

IGT recommends $1.5 million to apply the RENUGAS technology and IGT's existing process research unit to the gasification of RDF, directed toward both electric power and methanol production.

GREENHOUSE EFFECT:

Photosynthesis is a natural process for recycling and fixing carbon dioxide, and hydrocarbon-producing algae are very efficient in that process. Current algae systems bubble carbon dioxide through shallow ponds, requiring large surface areas and limited to daytime operation. IGT proposes that carbon dioxide from a fixed point source such as a power plant can be scrubbed to produce carbonate or bicarbonate solutions, a more readily usable and efficient carbon dioxide source for algae. In an attached film reactor (AFR), a thin film of algae will be attached to an inclined surface and sprayed with the carbonate or bicarbonate solutions. The spray will feed the algae as well as wash mature algae and the hydrocarbons that have been produced into collection facilities for separation and use. This system will allow continual carbon dioxide control and will reduce land requirements by an order of magnitude.

IGT recommends $0.5 million to produce a more active algae and evaluate the attached film reactor concept using carbonate and bicarbonate solutions as a means of reducing carbon dioxide released to the atmosphere from point sources.

GEOPRESSURED/GEOTHERMAL ENERGY:

In 1987, the United States used 17.6 trillion cubic feet of natural gas. The U.S. Geological Survey has estimated that 5700 trillion cubic feet of natural gas exist in geopressured/geothermal brines in porous sandstone formations in the U.S. Gulf Coast area. If even 10% of the gas present in the sandstone can be recovered, it represents an additional 30 years of domestic natural gas supply at current rates of use. In addition, an equal amount of thermal energy is estimated to be available from the hot brines.

Production of geopressured/geothermal methane involves drilling a well into a productive geopressured zone and bringing

to the surface a mixture of hot brine and methane. On the surface, the mixture is reduced in pressure, causing the gas to separate from the brine, yielding approximately 30 ft^3 of methane per barrel of brine. The brine is then injected back into a saline aquifer.

The current DOE program involves two wells in Louisiana, Gladys McCall and Hulin, and one in Texas, Pleasant Bayou. During the coming year, the program will address issues such as:

- maximum brine and gas production rates;
- productive lifetimes of given reservoirs;
- optimum production strategies to maximize energy recovery;
- techniques to control scaling and corrosion from the brines; and
- long-term capacities of disposal aquifers.

IGT recommends $8.4 million for FY90 to continue the scientific data acquisition and analysis at these three geopressured/geothermal wells, including the analysis of historic data.

This concludes my testimony. I have submitted more extensive fact sheets and summaries for these recommendations, and I would be happy to answer any questions or provide further information for members of this Subcommittee.

Selected Energy Research

Recommendations FY'90

PROGRAM FACT SHEET

MOLTEN CARBONATE FUEL CELL STACK PROGRAM

An integrated coal gasifier/molten carbonate fuel cell power plant can use abundant domestic coal to produce electricity at an efficiency approaching 55% compared to 33% for conventional systems and 45% for other advanced electric power generating technologies. It will achieve this with lower carbon dioxide emissions, negligible sulfur and nitrogen emissions, and at potentially lower cost than other competitive technologies.

A fuel cell takes in fuel and air or oxygen and directly produces electricity by means of an electrochemical reaction. The fuel cell's modular nature allows its use in a wide range of sizes and applications, from a few hundred kilowatts to multimegawatts, and from small on-site natural gas fired cogeneration systems to coal gas fueled baseload utility power plants.

The Department of Energy is supporting the development of three molten carbonate fuel cell (MCFC) concepts. Each of these concepts is different and all are in the developmental stage. While it is too early to determine the commercial viability of the three approaches, early analyses are very promising.

The IMHEX™ concept developed by IGT is designed and engineered to take advantage of IGT's extensive knowledge in MCFC technology, and has addressed and resolved many of the technological difficulties faced by the MCFC community. IMHEX is the only internally manifolded approach being developed in the U.S. This approach gives advantages in ease of cell assembly, method of charging the electrolyte, carbonate management, and efficiency of cell sealing. The separator plate and all active components are designed to allow for cost effective manufacture.

The current IGT stack test program has successfully demonstrated the viability of the IMHEX concept. No problems have been experienced in carbonate management or with the stack adapting to the changes in stack dimensions which occur during the operation of all MCFC stacks.

Additional developmental efforts are needed on the IMHEX concept to:

- improve tolerances in the manufacturing operations;
- scale up component manufacturing and stack testing from 1 ft^2 to full size; and
- improve component endurance to achieve a 40,000 hour stack life.

In addition to the three stack development contracts, DOE should have separately contracted technology base efforts addressing concerns common to all MCFC approaches.

IGT recommends $24.0 million to be evenly divided among the three existing MCFC stack contractors for development, scale up, manufacturing, endurance and large scale component testing. IGT also recommends $1.0 million to expand technology base research including the continuation of existing contracts for alternative anodes and corrosion prevention.

SOLID STATE PROTON CONDUCTOR FUEL CELLS

The Department of Energy initiated a contract with the Institute of Gas Technology in mid FY88 to evaluate the potential of high temperature proton conducting materials for use as a novel advanced fuel cell.

This long term, high risk program is expected to result in a solid state proton conductor (SSPC) fuel cell that has superior efficiency, cost and life over other emerging power generating technologies. In the SSPC, water, a product of the electrochemical reaction occurring in any fuel cell, will leave the fuel cell with the oxidant, and not with the fuel. This prevents the fuel dilution that occurs in solid oxide fuel cells and produces a higher electrical generating efficiency. Because it is a solid state device, the SSPC will have low maintenance, high performance and long lifetime. It is also expected to have high tolerance for contaminants in the fuel.

The SSPC will use a new class of ceramic materials, perovskites. The results of this project will determine the potential for this class of materials to be used in new highly efficient devices and sensors such as hydrogen pumps, hydrogen sensors, membrane separators for gas separation, and electrolyzers to produce hydrogen from water.

IGT recommends $0.5 million to continue the evaluation and development of the Solid State Proton Conductor fuel cell.

COAL-BED CHARACTERIZATION FOR ENHANCED METHANE PRODUCTION

Significant amounts of natural methane gas were generated and trapped as coal was formed. An estimated 300-500 TCF of this trapped gas is recoverable. Historically, coal bed methane was vented to the atmosphere to reduce the safety hazards in coal mines. A small amount of coal bed methane is now being produced commercially from a limited number of reservoirs.

Methane is not uniformly present in all coal beds. Two scientific factors are critical for its economic production. First, significant quantities of gas must have been generated and trapped to form a reservoir. Second, the gas must be able to move through the coal at flow rates sufficient to support a commercial well. Better knowledge of both of these factors is necessary to evaluate and recover the maximum amount of natural gas present in the extensive U.S. coal resources.

Two distinct but related topics are important when considering where coal bed methane would have been formed and subsequently trapped. These are:

- the relationship between coal type and rank and the composition and quantities of volatile substances, and
- the influence of coal grade and type on the retention of gas in the coal bed.

Work at the School of Mines and Energy Development at the University of Alabama has shown that relationships among coal composition, rank and gas content can be recognized in Alabama coals. Expansion of these studies to a wide variety of coals in various coal basins throughout the U.S. would improve the predictive value of the correlations. The West Virginia University will perform mechanistic correlations relating coal properties and gas content and producibility.

The flow rate of gas through a coal seam depends on the physical properties of the natural fractures present in the coal, as well as the sensitivity of the fractures to increased stress as gas is produced from the seam. The Institute of Gas Technology has developed and applied specialized techniques to study the geological properties affecting the productivity of various tight gas reservoirs. A better understanding of the geoscience of coal bed methane production will lead to the improved predictability of the production potential of these resources and will increase the recovery of domestic coal bed methane gas.

IGT recommends $1.0 million for a joint geoscience research effort with IGT, the School of Mines and Energy Development of the University of Alabama, and the University of West Virginia to determine, in a wide variety of coal seams, the correlations between geological properties such as coal type and rank, and amounts of recoverable methane.

DEVELOPMENT OF AN ADVANCED PROCESS FOR MILD GASIFICATION OF COAL

Although coal represents about 75% of the energy content of U.S. fossil fuel resources, less than 25% of the primary energy consumption is met with coal. A sound approach to a comprehensive national energy policy should include a broader use of our coal resources. Part of that strategy should include coal's use for applications other than simply as a fuel.

Most coal technology development in the U.S. has been oriented toward coal use in baseload electric power generation. One exception is the Department of Energy's program in mild gasification. This technology would be a significant benefit to the coal industry. It would allow coal to be used for new value-added products.

In mild gasification, coal is heated to moderate temperatures and pressures to produce gaseous fuels, a liquid hydrocarbon condensate and a solid char. The gaseous fuels are consumed to sustain the process and the condensate and char are used as raw materials for other processes, making them more valuable than if they were used solely as a fuel. The char may have uses in steel making, in water or waste water treatment, or as a "smokeless fuel" for either domestic or export use. The condensate can be used as a chemical feedstock and studies are underway to determine its use as a high energy density fuel for military applications.

Under DOE contract, The Institute of Gas Technology is heading a team of Peabody Holding Company, Bechtel National and Caterpillar to develop an advanced mild gasification process. IGT is constructing a 100 lb/hr process development unit using innovative gasifier technology. This technology will maximize the yield of the value-added co-products. The project has performed a market study which shows that there is good demand for the products that will be produced from the IGT process. Char utilization tests planned for the program will confirm the suitability of the char as a replacement for coke in the resurgent U.S. steel industry.

In order to determine economics and environmental and technical performance, as well as produce product for manufacturers to test, it is necessary to advance the IGT mild gasification process to the design, construction and operation of a 24 ton/day, mine-mouth process demonstration unit. Selected coals, representative of major U.S. coal resources, will be tested in the demonstration unit. The demonstration unit will also provide continuous operational data for process scale-up, as well as for construction and operation permits. The West Virginia University will provide specialized research support activities.

IGT recommends $0.4 million for the completion of the initial IGT mild gasification test program; and $3.0 million for initiating the engineering design of, and procurement of selected long-lead items for a cost shared 24 ton/day PDU based on the IGT concept.

TWO-STAGE FLUIDIZED-BED/CYCLONIC COMBUSTOR

Clean coal combustion processes are becoming more important in efforts to shift more of our energy demand to coal. These processes can produce two types of environmental impacts, emissions of gases into the atmosphere and production of solid wastes. Successful advanced coal combustion processes will have to address both of these environmental issues while maintaining high efficiencies and the lowest possible costs.

Commercial and developmental coal combustors can be grouped into two classes, those that operate under pressure and can be used in combined cycle power plants and those that operate at atmospheric pressure and are used in simple cycle operations.

There are two types of atmospheric pressure combustors, fluidized bed and slagging combustors.

Existing atmospheric pressure fluidized bed combustion technologies have two persistent ash problems that affect their efficiency. In order to prevent ash from sticking in the combustor, they must operate at relatively low temperatures. These low temperatures make heat transfer to the steam cycle less efficient. The combustion gases from atmospheric fluidized beds also carry large amounts of ash to the heat exchangers, depositing a layer of ash that lowers the efficiency of heat transfer. The combined effect of these two problems requires the use of larger, more costly equipment to recover the energy for steam and electricity production.

Slagging combustors operate at high temperatures. They have difficulty with simultaneous removal of both SO_x and NO_x while achieving acceptable slag removal.

To get around these concerns, DOE is developing pressurized fluidized bed combustion systems to improve the energy efficiency.

IGT has invented and patented an alternative, promising approach, an advanced two-stage coal combustor capable of either atmospheric or pressurized operation, which should minimize environmental impacts while maintaining high efficiencies. This approach combines IGT's unique technology and experience in fluidized beds and cyclonic combustion to simultaneously control SO_x and NO_x emissions and create an easily disposable solid residue.

The first stage of this combustor will consist of a fluidized bed in which sulfur is removed by limestone addition and NO_x formation is prevented by controlling temperature and the quantity of oxygen present. Use of IGT's patented sloping grid design allows the combustor to operate at higher temperatures than conventional fluidized beds and also provides for high ash discharge from the bottom of the fluidized bed. Over 98% of the ash and limestone residue will be removed in this first stage so that the gases leaving the first stage will contain very little solids.

The second stage, a cyclonic combustor, will combust the remaining gases and separate the solids prior to the heat exchangers, eliminating the efficiency loss caused by ash deposits on the heat exchangers. The following performance

is predicted:

ash rejection in first stage	greater than 98%
NO_x emissions	less than 150 ppm
CO emissions	less than 100 ppm
sulfur reduction	greater than 90%

This combustor approach can be designed for either atmospheric or pressurized applications. The atmospheric pressure version will be used to replace individual utility burners for retrofit applications since it is expected to be smaller than existing fluidized bed combustors as a result of its reduced air requirements and relatively high combustion temperatures. The high pressure version will be able to be used in a combined cycle power plant to produce electricity at high efficiency with relatively simple equipment.

It is expected that the combustor will be able to use a wide range of feedstocks ranging from coal to coal wastes, peat, and refuse derived fuels.

Additional development is needed for integration of the two stages and optimization of the resulting two stage combustor at pressures ranging from atmospheric to 450 psi. This work can be performed using IGT's existing 6 million Btu/hr sloping grid fluidized bed facility.

IGT recommends $1.0 million for the development of an advanced two stage coal combustor based on IGT's sloping grid fluidized bed and cyclonic combustion technology, making use of existing PDU facilities.

EASTERN OIL SHALE

R&D PROGRAM RECOMMENDATIONS, FY90

Process Research

Eastern Oil Shale occurs in Alabama, Kentucky, Ohio, Indiana, Michigan, and Tennessee. The necessary mining infrastructure and water resources are available and the Eastern United States offers a close and ready market for liquid fuel products. Conventional thermal retorting technologies, however, cannot economically produce liquid fuels from eastern oil shale.

Tests have shown that retorting eastern oil shale in the presence of hydrogen dramatically increases the yield of oil compared to conventional thermal retorting. A multi-disciplinary team (Institute of Gas Technology, University of Alabama's Mineral Resources Institute, University of Pittsburgh, Illinois Institute of Technology, Ohio State University, Tennessee Technological University and the University of Michigan) has been advancing this concept under DOE contract by developing a new retorting technology known as pressurized fluidized bed hydroretorting (PFH).

Results to date are very encouraging. Applying the PFH process to Indiana New Albany shale produces twice the oil yield of conventional thermal retorting. The PFH process also achieves higher oil yields and uses less hydrogen than moving-bed hydroretorting, an alternative retorting approach for eastern oil shale. Therefore, the PFH process should be more economic than other eastern oil shale retorting processes.

To support the oil productivity increases of the PFH process, the project team is developing supplemental technologies including shale beneficiation, gas clean-up, shale oil upgrading and environmental impact mitigation.

Removal of solids from a high pressure retort such as that used in the PFH process is traditionally an inefficient and maintenance intensive operation. During the first year of the current project, IGT has developed a Restricted Pipe Discharge System (RPDS), which is more efficient and economical than conventional systems.

Another problem common to attempts to recover oil from any oil shale is its high inert mineral matter content. Removal of the mineral matter prior to retorting improves the efficiency and economics of the PFH process. Beneficiation research is being conducted by the Mineral Resources Institute of the University of Alabama and the University of Pittsburgh. This research shows that an advanced beneficiation process using column flotation increases oil yield potential in the retort to over 260% of that obtained when an equal quantity of non-beneficiated shale is used. PFH economics are further improved because of a 60% reduction of the sulfur content of the shale after beneficiation. In addition, column flotation achieves 20% better kerogen concentration and higher kerogen recovery in equipment one-eighth the size of that required by previous beneficiation techniques.

The PFH process requires use of hydrogen at elevated temperature and pressure. Conventionally, hydrogen is produced in a complex, five-step process starting with natural gas, which requires the gases to be repeatedly heated or cooled between process steps. This results in lower energy efficiencies and higher costs. IGT has developed and patented a high-temperature metal foil membrane process which should reduce the five gas processing steps to only one step. This process can be used at high temperature, retaining high thermal efficiency. It can also be used to recover unreacted hydrogen for reuse in the PFH process. This process needs further development and scale up for this application.

IGT has also developed another process for reducing hydrogen consumption, resulting in lower cost of finished products from oil shale. Hydrogen is used to remove sulfur and nitrogen from shale oil produced by any retorting process, adding a significant cost to producing saleable oil from oil shale. IGT has developed and successfully tested a novel catalyst to remove the sulfur and nitrogen using mixtures of methane and carbon dioxide instead of expensive hydrogen. This technology has been proven on upgrading coal derived liquids, but additional studies are needed to apply the technology to upgrading shale oil.

In order to determine the economics and environmental impact for a total eastern oil shale processing including mining, beneficiation, retorting and water and waste solids management, the PFH process must advance to design, construction and operation of a 4 ton/hour truck transportable process development unit. This unit would be moved to various shale sites to obtain operation data. It will also provide data for process scale-up and construction and operation permits.

IGT recommends $3.0 million for continued development of the PFH process including the use of the foil membrane in hydrogen production and use of carbon dioxide methane mixture in shale oil upgrading, and $1.5 million to initiate design and engineering of a 4 ton/hour transportable PFH process development unit.

The work conducted at a field research station in Montgomery County, Kentucky, uses large concrete lysimeters to determine the elemental release or leaching characteristics of the materials. Shale materials are capable of forming acidic drainage and releasing environmentally sensitive elements in high concentrations, pointing out the need to further reduce the carbon and sulfur content of the shale to eliminate these hazards.

It is necessary to evaluate the disposal of spent oil shale with the characteristics of those from advanced technologies in large field and laboratory lysimeters. The lysimeter data will be incorporated with other information in a Systems Management Model to develop a flexible method for assessing the economic and environmental impact of various oil shale disposal methods.

The fully instrumented field research site operated by CAER will be used to study southern Indiana New Albany Formation oil shale that has been subjected to retorting and fluidized bed combustion. This material is similar in nature to that produced from an advanced eastern process such as KENTORT II and is available in sufficient quantity for meaningful field research.

The materials will be installed in the field lysimeters to duplicate a disposal pile. The chemistry of the leachates, generated under completely natural conditions, will be determined over several years and the physical changes of the shale will be documented. Additional lysimeter experiments will be conducted in the future at the University of Wyoming indoor lysimetry facility. This unique installation allows the environment to be completely controlled and the effect of extreme conditions, which cannot be expected in a short duration field study, will be assessed.

To ensure that the environmental studies are as useful as possible, a Systems Management Model approach will be utilized. The field data along with hydrologic, mineralogic, soil characterization and mine and retorting technology information will be integrated into a computerized model. This will allow the impact of chemical changes in the spent shale, along with variations in disposal practices and spent shale utilization options, to be easily assessed. The model and the fundamental data generated will also have applicability in the management of other energy related solid wastes.

IGT recommends $1.5 million to conduct environmental studies which would include University of Kentucky efforts to assess mitigation of the impacts of retorted, spent shale.

Novel Concepts Research

At the end of FY86, three awards were made by DOE for research on novel concepts for oil shale processing. One of the projects was for research on an inert-gas, atmospheric-pressure fluidized-bed retort system being developed by the University of Kentucky Center for Applied Energy Research (CAER). The conceptual process, called KENTORT II, is a multiple fluidized bed process which improves oil yields from eastern oil shales over conventional technologies, produces valuable chemical by-products and decreases environmental problems associated with spent shale disposal. It incorporates three stages: pyrolysis, gasification and combustion.

Crude shale oil, the primary product, is produced in the pyrolysis zone. The gasification stage treats the shale for efficient and clean combustion, provides heat for pyrolysis by recycling the hot spent shale, and converts the spent shale into a more environmentally acceptable material. The combustion zone at the outlet of the gasification stage burns the unreacted carbon from the shale to provide the energy needed in the other stages. The results obtained so far in a 5 lb/hour integrated reactor system are very encouraging, showing oil yields up to about 150 percent of those expected from conventional thermal retorting at similar conditions.

Scale up of the KENTORT II process is necessary in order to better simulate the performance of a commercial system, produce larger quantities of shale oil and spent shale for testing, and determine engineering design parameters necessary for commercialization.

An additional novel concepts solicitation which does not require co-funding by the research teams should be issued in FY90.

IGT recommends $2.0 million for continuing novel concepts research, including efforts to extend the data base for the KENTORT II process.

Environmental Studies

Responsible technology development requires continuing environmental research to assure that the development of new technologies will not create adverse environmental impacts. Such studies should be continued during the development of the oil shale beneficiation and retorting and shale oil upgrading parts of this program.

The new technologies being developed under this program will produce spent shales which are physically and chemically different from those of previously studied conventional technologies. Obviously, environmental safety is essential for implementing an oil shale industry. Research in this area should be conducted simultaneously with process development so environmental solutions can be integrated into process design.

For the past five years, the University of Kentucky CAER has conducted research on the environmental characteristics of retorted eastern oil shale, with support from the Commonwealth of Kentucky and the DOE. The retorted oil shale was produced from a conventional technology originally designed for western U. S. oil shale. This effort has focused on the geotechnical, leaching and reclamation characteristics of the spent shale.

ENRICHED METHANE PRODUCTION FROM ANAEROBIC DIGESTION OF SOLID WASTE OR BIOMASS

Solid waste disposal is an increasing problem in the United States with landfills reaching capacity and alternatives such as incineration experiencing environmental problems. One alternative to incineration is biological conversion of municipal solid waste to methane, a clean burning fuel.

Conventional single-stage anaerobic digestion is a process long employed by industry and municipalities which uses microorganisms for pollution control and sludge stabilization. However, it produces a product gas that contains 60% methane and 40% carbon dioxide. The cost of removing the carbon dioxide to produce a pipeline quality gas (greater than 95% methane) from this mixture is prohibitive, ranging from $1.50 to $3.00 per million Btu.

Pressure swing absorption is a technique that is used to purify gas streams. It uses the difference in the solubility of a gas in a liquid at two different pressures to remove the unwanted gases. Integration of this technique with single stage digestion would eliminate the costly separation step. However, application of pressure swing absorption will increase the pH in the digestor requiring additional chemicals to control the pH within the range needed by the microorganisms. This will represent an additional chemical cost of approximately $2.50 per million Btu of gas produced.

IGT has successfully tested carbon dioxide removal from the product of single stage anaerobic digestion of sewage sludge, under GRI/DOE contract. This is an important step towards producing pipeline quality methane gas from anaerobic digestion.

Use of two stage anaerobic digestion instead of single stage anaerobic digestion in combination with pressure swing absorption will eliminate the chemical cost required by single stage anaerobic digestion and also allow the use of smaller and more economic equipment because of the higher reaction rates in two stage anaerobic digestion.

Pressure swing two-stage anaerobic digestion promises to be the most economic means of producing a pipeline quality methane gas from solid waste or biomass since it eliminates both the need for carbon dioxide removal from methane and the use of chemicals for pH control.

IGT recommends $0.5 million to develop an integrated pressure-swing two-stage anaerobic digestion system based on the GRI concept using an existing PRU to economically produce pipeline quality methane from solid waste and biomass.

PRESSURIZED GASIFICATION OF REFUSE DERIVED FUELS

The disposal of municipal solid waste is becoming an increasingly crucial issue. Historically, solid wastes have been disposed of in landfills. However, in an attempt to reduce the volume of solid wastes and thereby increase the life of landfills, technologies have been developed and deployed for recycling and electric energy generation.

Waste-to-energy facilities primarily use mass-burn technologies, incinerating wastes to heat water to produce steam for generating electric power. Some waste-to-energy facilities manufacture refuse derived fuel (RDF) which is produced by removing the non-combustibles from municipal waste, producing a product to be used either alone as a fuel or as a supplement to coal in boilers.

Current mass-burn technologies still need improvement. Plants have suffered extended shutdowns for problems in fuel handling and ash removal. Serious questions have been raised regarding their emission of hazardous air-borne pollutants. Consequently, there is still a need for alternatives to the mass-burn concept.

The use of RDF as a supplement to coal has suffered from unfavorable economics. Because of the high ash content of RDF, using it with coal results in increased boiler maintenance, eliminating the incentive for a coal boiler operator to use RDF.

IGT has developed RENUGAS, a pressurized, fluidized-bed process for the gasification of biofuels which can be applied to the gasification of RDF. Using RENUGAS to gasify RDF as part of a combined cycle power plant will allow the use of municipal solid waste to produce electricity in a highly efficient, environmentally sound manner.

The use of RENUGAS allows the conversion of RDF to electricity without the release of harmful emissions or the creation of dioxins. Power generation efficiencies up to 45% are expected from RENUGAS RDF gasification compared to efficiencies up to 33% from mass-burn steam cycles. This efficiency increase will result in a 25% decrease in the amount of CO_2 released for the same amount of electricity produced.

The RENUGAS process can also convert RDF into a synthetic gas that can be used to create methanol, which can then be used to generate electricity, as a transportation fuel, or as a chemical intermediate.

Another problem with mass burn facilities is that they are only economic at large sizes, limiting their usefulness to large metropolitan areas or regional facilities. A RENUGAS combined cycle power plant will be available in a wider range of sizes. This would make the technology and its environmental benefits available to a broader range of users.

IGT recommends $1.5 million to apply the RENUGAS technology and IGT's existing process research unit to the gasification of RDF, directed toward both electric power and methanol production.

CARBON DIOXIDE REMOVAL USING HYDROCARBON PRODUCING ALGAE

The trend toward global warming, known as the greenhouse effect, has been attributed in part to the increasing concentration of carbon dioxide in the atmosphere. Carbon dioxide is released into the atmosphere during the combustion of all fossil fuels.

Despite growing concern about the environmental effects of carbon dioxide release, we cannot readily abandon the use of fossil fuels. The economies of both developed and developing nations are dependent on fossil fuel use for energy needs ranging from transportation, electricity generation, and heating to manufacturing. Fossil fuels are also an essential part of the world's energy resources. Since fossil fuels are likely to be used for many years, means to either remove the carbon dioxide from, or prevent its escape into, the atmosphere are being considered.

Photosynthesis is a natural process for recycling and fixing carbon dioxide. One U.S. electric utility is attempting to balance the CO_2 produced from one of its power plants by agreeing to plant 52 million trees in Guatemala. This can only be considered as a slow, long term remedy and will require very large areas. The company estimates that two square miles of forest are required to mitigate carbon dioxide emissions from one megawatt of electrical capacity.

Another approach is to use hydrocarbon-producing algae to remove and fix carbon dioxide and obtain a storable and reusable energy source. Algae are an order of magnitude more efficient users of land area for carbon dioxide removal than are forests or crop plants. They also produce hydrocarbons that can be collected and converted to liquid fuel. The algae can be harvested and used for a variety of purposes. Other researchers are testing the use of large shallow ponds (up to 50 acres and 6 inches deep) for algae growth. This will require large areas of flattened land surfaces resulting in high site acquisition and preparation costs. Recovery of the algae from large ponds will also be costly. In the shallow pond concept, the carbon dioxide is bubbled into the pond and removed by the growing algae. During darkness, the algae will be less efficient, requiring the reduction of power plant output, the release of carbon dioxide into the atmosphere, or a fresh approach to begin to control carbon dioxide.

IGT recommends that carbon dioxide from a fixed point source such as a power plant can be scrubbed to produce carbonate or bicarbonate solutions, a more readily usable and efficient carbon dioxide source for the algae. This solution can be used to feed a thin film of algae in an attached film reactor (AFR). In an AFR, a thin film of algae, approximately 1 millimeter thick, will be attached to an inclined surface and be sprayed with the carbonate or bicarbonate solution during daylight hours. Mature algae will be washed down the incline, transporting the algae and the hydrocarbons they produce for collection, separation and use. The combination of using carbonate or bicarbonate solutions and the ATR technology should reduce the land requirement by an order of magnitude compared to the shallow pond approach.

The carbonate or bicarbonate solution can be collected whenever a power plant is in operation, sprayed directly on the AFR during the day and held in storage tanks at night. Hydrocarbons produced by the algae would be collected for use as a fuel.

IGT recommends $0.5 million to produce a more active algae and evaluate the attached film reactor concept using carbonate and bicarbonate solutions as a means of reducing carbon dioxide released to the atmosphere from point sources.

GEOPRESSURED/GEOTHERMAL METHANE

The U. S. Department of Energy has underway a project aimed at solving the technical issues associated with producing cost competitive natural gas and using the heat of the brines from the vast geopressured/geothermal resources present in the Gulf Coast area. Three wells are available to the project: Gladys McCall (LA), Pleasant Bayou (TX), and Hulin (LA).

This program requires the involvement of various organizations with expertise ranging from well operations, surface facilities and hybrid electric power plants to geology, physical chemistry, reservoir modelling, environmental studies and experimental data analysis. Participating organizations include: Eaton Operating Company, Institute of Gas Technology, the Ben Holt Company, University of Texas at Austin, University of Southwest Louisiana, S-Cubed, Louisiana State University, Southern University, Rice University, the Bureau of Economic Geology of the University of Texas at Austin and EG&G Idaho.

The project team has developed corrosion prevention treatments, specialized materials and brine handling equipment which have allowed the production of large amounts of hot brine and natural gas from the Gladys McCall and Pleasant Bayou wells. This proved the existence of these huge, previously unknown underground reservoirs. The results of this program also provide useful information for improving production of natural gas from conventional or watered-out reservoirs.

A power plant provided by EPRI which uses both the natural gas and thermal energy of the brine is being installed at Pleasant Bayou. This will be the first demonstration of electricity production using this resource. Following the power plant program, the brine will be produced at high flow rates to yield further information about the strength of the reservoir rock and the changes in the rock permeability as the reservoir pressure decreases.

The Hulin well has been refurbished and is ready for the installation of trial production and testing equipment. If the well proves capable of high flow rates, permanent production and testing equipment will be installed. The test program will expand the scientific understanding and modelling to this deepest and hottest of the three wells. It also may show the presence of free gas in addition to the gas dissolved in the brine. The presence of free gas would have a positive effect on the economics of geopressured/geothermal energy.

The final scientific testing program for the Gladys McCall well is underway to determine the effect on the reservoir of having produced over 27 million barrels of brine and 675 million cubic feet of methane during the DOE test program. The scientific understanding obtained will allow the prediction of the longevity of geopressured/geothermal reservoirs.

The scientific programs at all three wells should be continued, as valuable technical, environmental and economic information is being obtained from each well.

IGT recommends $8.4 million to continue the scientific data acquisition and analysis at the three geopressured/geothermal wells, Pleasant Bayou, Hulin and Gladys McCall, including analysis of historic data.

STATEMENT OF
THE AMERICAN GAS ASSOCIATION
BEFORE THE SUBCOMMITTEE ON ENERGY
RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE
ON THE FY 1990 DEPARTMENT OF ENERGY
RESEARCH AND DEVELOPMENT BUDGET
JULY 25, 1989

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The American Gas Association (A.G.A.) is a national trade association comprised of some 250 natural gas distribution and transmission companies serving millions of natural gas consumers throughout the United States. We appreciate this opportunity to present our views on natural gas-related research and development (R&D) conducted or sponsored by the Department of Energy (DOE), as addressed in S. 964.

The natural gas industry recommends an authorization of $125.80 million for all DOE gas-related R&D in Fiscal Year (FY) 1990. This total is broken down as follows: $73.40 million for fossil energy R&D; $39.0 million for conservation R&D, which includes $9.5 million for a natural gas vehicle R&D program; and $13.4 million for renewable energy R&D.

THE IMPORTANCE OF GAS-RELATED RESEARCH

The United States needs an adequately funded DOE research program not only to meet future energy needs, but also to remain competitive in today's world economy. Gas-related research may be the most important component of

DOE's research program.

Natural gas energy has an important future role because its attributes favor its use in a myriad of applications. First, gas is the cleanest of all fossil fuels. Gas can be used for pollution control by itself and to reduce sulfur and nitrogen oxide emissions of other fossil fuels. Gas can also be used as a vehicular fuel. No other single fossil fuel can be used in as many applications as natural gas without major negative environmental consequences. Indeed, the air pollution problems resulting from the combustion of other fossil fuels has caused many in Congress and the Administration to call for solutions to the ozone nonattainment, acid deposition, and potential global warming problems facing the nation today.

Second, natural gas can be delivered quickly, efficiently and without major environmental impact, through the existing million-mile transmission and distribution system.

Third, natural gas can be converted into usable energy more efficiently and inexpensively than other fossil fuels. The efficiency of current gas utilization technologies ranges from 98 percent for residential heating to 70 percent for industrial cogeneration and 50 percent for combined cycle turbine systems for electric generation.

DOE's role in gas research serves two very important purposes. First, DOE's support of gas supply-related

research will ensure the recovery of a larger percentage of the total gas resource base, which is several thousand times larger than the presently recoverable gas resource base. The amount of gas that may be recovered from the total gas resource base is directly contingent upon our ability to develop new tools and techniques to recover this gas at commercially viable prices.

In May 1988, the Department of Energy released a study entitled, "An Assessment of the Natural Gas Resource Base of the United States." This study concluded that, in the lower 48-states, there are 1,059 trillion cubic feet (Tcf) of gas that can be tapped with existing technology. At the 1987 level of nationwide gas consumption, this amount is equivalent to a 62-year supply. While the number is encouraging, and is indeed conservative, if natural gas is to be the cornerstone of the Administration's energy policy, technological breakthroughs will be necessary to increase long-term gas supplies dramatically. Federal funding is necessary to development of a long-term, high-risk technology base essential to achieve these breakthroughs.

We are pleased that Congress has recognized the importance of gas-related research. Over the past few years, Congress has consistently authorized and appropriated much more funding for natural gas R&D than the Administration has recommended, especially in the areas of unconventional gas recovery, geopressured resources, gas-

related fuel cells and gas-related conservation programs.

While Congress has recognized the need for a stronger geoscience program, the funding has not nearly been sufficient. DOE has made organizational and structural changes recommended by the February 1987 ERAB report to DOE, "Geoscience Research for Energy Security." Unfortunately, organizational changes alone are not enough. The most important recommendation by ERAB was a call for significantly higher funding levels for gas and oil-related geoscience research. To date, such dramatic funding increases in gas-supply related research programs have not materialized. Therefore, to truly implement a geoscience program as envisioned by ERAB, we recommend that Congress provide a strong funding base for cross-cutting geosciences research which will benefit both gas and oil exploration and production.

The second purpose of DOE's involvement in gas research is to provide funding for technologies that radically change the manner in which we use natural gas. Significant improvements can be made in the area of energy efficiency. Such improvements are at the cornerstone of many bills introduced in both the 100th and 101st Congresses. For example, further research on electrochemical processes and thermodynamics could improve the process for transforming gas into usable energy, with greater efficiency and no adverse environmental impact. DOE can and must play a

central role in gas technology development, in order for the U.S. to reduce its reliance on foreign oil, improve its energy efficiency to enable industry to compete in the global marketplace, and reduce pollution.

To facilitate DOE's role in natural gas energy research, A.G.A. recommends that there should be created within the Department a new Assistant Secretary position, the Assistant Secretary for Natural Gas. This person would coordinate vital departmental natural gas initiatives on both the supply and demand side. Many of the national goals that President Bush seeks can be enhanced by the creation of this position. This new Assistant Secretary for Natural Gas should be empowered to establish a natural gas policy for the nation and to coordinate it with all federal agencies. The new Assistant Secretary could direct all agencies, including independent regulatory agencies such as FERC, to consult with the Secretary/Assistant Secretary before taking any action that could affect the nation's natural gas policy.

SPECIFIC FUNDING RECOMMENDATIONS

FOSSIL ENERGY R&D: $73.40 Million

(1) Unconventional Natural Gas ($15 Million)

Large amounts of natural gas have been identified in tight geological formations such as Devonian shales and tight sands. Devonian shales and tight sands are estimated to contain more than 1,800 Tcf and 900 Tcf of natural gas, respectively. Tight formations gas is produced using unconventional recovery techniques. A.G.A. estimates that favorable economic conditions and substantial investment in advanced recovery techniques could result in annual "incremental" production of up to 4.0 Tcf of gas by the year 2000, while the current rate of technology would produce approximately 1.0 Tcf by that year.

In order to optimize the amount of natural gas recovered from our abundant resource base, basic geoscience research must be expanded. This research should be aimed at increasing our knowledge of the geological/geochemical/geophysical characteristics and parameters of both conventional and unconventional formations. This cross-cutting, reservoir characterization-type research is essential to both exploration and production in new formations, which are characterized by subtle traps, and to the application of secondary recovery techniques in existing fields.

Moreover, because of the potentially enormous size of what we call advanced unconventional natural gas resources

(e.g., gas hydrates and deep source gas), extensive research is necessary just to verify how much may be technologically and economically recoverable. For instance, early R&D efforts in the area of gas hydrates and deep source gas will help define the scope of the resource.

To enhance the development of technology necessary to recover the natural gas from unconventional gas formations, more research must also be conducted to develop advanced stimulation techniques to fracture tight rock formations that restrict gas flow. Current fracturing techniques induce only shallow fractures of a few hundred feet. Field testing must be conducted to refine techniques for inducing deep fractures of several thousand feet and to control the direction of the fracture better for optimal production results.

Also, research information must be collected from field testing to establish a technological database for simulation modeling, economic modeling and other analytical purposes. In addition, advanced drilling techniques (directional and horizontal) must be refined and improved to increase production rates and reduce drilling costs. We are recommending funding of $15 million in the unconventional natural gas recovery program to continue DOE's secondary gas recovery program and ongoing research activities in western tight sands, Devonian shales, and other complex formations and to support expanded geoscience-type research.

(2) Surface Coal Gasification ($3.4 Million)

Surface coal gasification is an important technology that can augment future natural gas supplies. A.G.A. projects that, by the year 2000, surface coal gasification has the potential to contribute approximately 100 billion cubic feet (Bcf) of additional gas supplies. However, with vigorous R&D support, surface coal gasification could contribute up to 200 Bcf to our supplies.

Contemporary technologies allow significant production of gas from coal; however, substantial research into the gasification process is necessary for synthesized gas from coal to play a role in meeting this nation's future energy needs. Gasification techniques must be developed to accommodate high-sulfur Eastern coals and combustion-inhibiting coal "fines." Research must be conducted to develop techniques for gasifying these "fines," for disposition of liquid byproducts, and for consolidating "fines" and tars for utilization.

Scientific and engineering feasibility studies of advanced generation gasification processes must also be conducted to develop a technological database for such processes. In addition, research must be conducted to identify the proper treatment and disposal techniques for gasification waste byproducts.

(3) Fuel Cells ($36.5 Million)

Natural gas-powered fuel cells, in a highly efficient electrochemical process, convert the energy content of gas directly into electricity and byproduct heat. The electrical conversion efficiency of gas-powered fuel cells is approximately 15-20 percent greater than the conversion efficiency of traditional electrical generation. Combining fuel cells with certain cogeneration applications could achieve combined electrical and thermal conversion efficiencies of 80 percent, compared to conversion efficiencies of 30-35 percent by conventional central station electric plants. Fuel cells are also environmentally benign, emitting virtually no pollutants. As work on the phosphoric acid fuel cell reaches its conclusion, the gas industry's focus is directed toward the development of advanced fuel cells, which will operate at higher temperatures making them conducive to industrial applications and achieve even higher efficiencies.

Research must be conducted to develop second-generation molten carbonate fuel cells capable of processing gases containing various impurities, as well as to develop other advanced, direct conversion concepts, such as solid oxide fuel cells. Because of its importance, we recommend a total of $36.5 million for fuel cells of which $25 million should be used to support development of molten carbonate fuel cells, $9.5 million for continued development of advanced

concepts such as solid oxide fuel cell technologies, and $2 million for an advanced technology base for phosphoric acid fuel cells. The second and third generation fuel cell concepts are still years away from commercial use and, therefore, are critically dependent upon continuity of federal R&D support to supplement industry efforts.

(4) Heat Engines ($10.0 Million)

Because of their contribution to the environment and energy conservation, we recommend a research and development program in DOE's Heat Engine Program for the development of high efficiency natural gas-powered turbines for electric generation. Such a program should include advanced combined cycle gas turbines, steam-injected gas turbines (STIG) and intercooled steam-injected gas turbines (ISTIG). The ISTIGs, in particular, are fifty percent more efficient than conventional powerplants, and cost half as much as new coal or nuclear plants and can make great contributions to the nation's clean air problems. Two million dollars of this is for research on combustion systems emissions control.

(5) Underground Coal Gasification ($2.5 Million)

Underground coal gasification is the process whereby coal is burned underground, in formation, generating a low-Btu or medium-Btu gas. The coal is gasified by drilling boreholes into the coal seam, igniting the coal and

injecting air, steam or oxygen into the reaction zone. The hot gas is forced through the seam to an exit borehole where it is carried to the surface and processed to remove impurities. The gas can then be used directly as an energy source or can be upgraded to pipeline quality through catalytic methanation and subsequent gas processing.

Underground coal gasification could substantially increase the nation's coal resource base, 93 percent of which presently cannot be recovered economically using conventional mining techniques. Moreover, underground coal gasification offers potential environmental, economic and safety advantages over conventional mining.

Extensive field testing is necessary to understand the technological basis for linking the vertical wells through the coal seam and controlling the movement of the reaction zone. Extensive environmental monitoring is also required to analyze and control the potential contamination of surface water and local aquifers, and to control surface subsidence.

To date, DOE sponsored field tests of the controlled-retracting-injection-point (CRIP) technology have been successful and we must now analyze the results of these tests, determine if this technology is applicable to other coal seams, and complete environmental work at the test site. This technology needs to be demonstrated now on Eastern bituminous coals.

(6) Advanced Research & Technology Development ($6 Million)

The Advanced Research and Technology Development program generally supports basic research in combustion chemistry, engineering concepts and materials and components that provide a technology base for ongoing fossil energy projects and for advanced process development, such as coal gasification and fuel cell systems. Current research needs include: improving the understanding of the interactions of coal gasification processes in a fluidized-bed environment; improving the understanding of the interaction of gasification catalysts with carbon/steam and carbon/hydrogen reactions; developing advanced processes for low-cost synthesized gas; developing lower-cost acid-gas cleanup processes; and continuing efforts to assess advanced cleanup technology for alkali metals, particulates and tars.

CONSERVATION: $39 Million

(1) Natural Gas-Powered Heat Pumps ($10 Million)

By extracting heat from the outside air and transferring it to the indoor space, gas heat pumps can actually supply more thermal energy than is contained in the fuel that they use. The gas heat pump's cooling effect is accomplished by reversing this process. The gas heat pump provides heating and cooling in a single unit using less energy than a conventional or high efficiency furnace uses for heating alone. Current performance estimates suggest

that in heating, the gas heat pump could save one-half of the gas used in a conventional furnace and one-quarter of the gas used in a high efficiency furnace.

More research is necessary to develop highly-efficient, reliable and cost-effective gas heat pumps for residential and commercial applications. In order to improve durability, maintenance and endurance, such research must include the evaluation of promising technical approaches, fundamental research in basic heat pump concepts, processes, phenomena and materials, and research on generic component development. These activities must be integrated into overall gas heat pump system development and analysis. Presently, the most promising gas heat pump concepts are the dual cycle absorption concept, absorption technology using fluids in novel cycles, and engine driven concepts using improved and emerging internal combustion technology.

(2) Natural Gas Vehicles (NGVs) ($9.5 Million)

Development and utilization of vehicles powered by compressed natural gas would serve the national interest by improving air quality, since the emissions from natural gas vehicles (NGVs) contain only a fraction of the nonmethane hydrocarbons, carbon monoxide, and nitrogen oxide produced by gasoline-powered vehicles. Furthermore, unlike gasoline-powered vehicles, NGVs emit almost no sulfur oxides or particulate matter. Fleet use of NGVs in congested cities

would provide a significant benefit to those areas where air quality improvement is most critical. In addition, substantial potential exists for emissions reductions from diesel engines through the use of natural gas/diesel fuel mixtures in those engines.

Conversion to partial or dedicated natural gas/heavy duty diesel engines holds the promise of a low-emissions engine, but further R&D is required to address the well recognized technical difficulties. Moreover, the technology-forcing EPA particulate emissions standards effective in 1991, make development of advanced, dedicated natural gas-powered heavy duty engines imperative.

Congress recognized the need for developing natural gas-powered heavy duty trucks and buses when it passed the Alternative Motor Fuels Act of 1988 which authorized $6 million for the development and demonstration of alternative fueled trucks and buses. In addition to funding this activity, however, additional funding is needed to conduct R&D on natural gas vehicles in general.

Fundamental research is necessary to acquire a thorough understanding of the intricacies of gaseous fuel injection, carburetion, manifolding, combustion, power optimization and emissions control so that natural gas can become broadly accepted as a transportation fuel. Further research into novel gas compression concepts is necessary to advance the development of compressor technology. Research must also be

conducted on advanced storage systems (e.g., sorbent materials) to increase the understanding of gas storage technology, particularly the fundamental principles of natural gas adsorption, absorption, clathration and catalysis.

(3) Other Projects ($19.5 Million)

Other research projects that are included in our conservation recommendation of $39 million are: (a) $3.0 million for DOE research on indoor air quality; (b) $8.5 million for tribology, ceramics, and other materials-type research in the energy conservation utilization technology program (ECUT); and (c) $8.0 million for research on desiccant technology that is used in gas cooling.

RENEWABLE ENERGY: $13.4 Million

(1) Geopressured Methane ($8.4 Million)

Geopressured methane is found in either a free state or dissolved in water and trapped in sedimentary rock at higher-than-normal pressures. One of the largest geopressured areas underlies a portion of the Texas and Louisiana Gulf Coast. Estimates of the total resource in-place range up to 100,000 Tcf; however, estimates of the amounts of gas that might ultimately be recovered, given current recovery techniques, range between 25 and 1,200 Tcf. If technological breakthroughs can be achieved, geopressured

methane could become a virtually inexhaustible source of domestic energy.

Research conducted by DOE in geopressured/geothermal zones is focused on producing both gas and electricity from low-grade heat in the reservoir brine. DOE should redirect its research efforts and concentrate more on recovering the vast amount of dissolved methane found in geopressured zones. In addition to DOE's current geopressured program, DOE should develop new approaches that utilize traditional engineering principles to maximize gas production and minimize brine production.

(2) Biofuels ($5 Million)

Since the supply of organic and waste materials is virtually unlimited, supplemental methane supplies from biomass and waste conversion can add significantly to the total future gas supply picture. Finding sites for disposal of waste is an increasing problem in communities across the nation. The New York garbage barge this past year is a graphic example of the enormity of the problem. Therefore, developing energy from biomass would promote the environmental benefit of productive use of currently "useless" materials. However, the quality of the gas produced and a suitable processing technique are important concerns that inhibit the widespread use of these potential gas resources.

The gas industry fully supports the gas-related biofuels R&D being carried out at the Solar Energy Research Institute (SERI) and recommends strong federal support for continuation of these important activities. Advances have been made in both the thermochemical and biochemical conversion processes, but more extensive studies and technology advancements are necessary to fulfill biomass' contribution as a useable source of energy.

Of particular interest to the gas industry is SERI's work in the biotechnology process of anaerobic digestion of municipal solid waste that includes genetic and other improvement of biological organisms and development of innovative reactor design concepts.

Another significant area of research at SERI includes methods to remove carbon dioxide from the air or from combustion plant stacks. $5 million is needed to perform these two gas-related initiatives in FY 1990. We also urge Congress to provide a strong, stable funding level for all biofuels research work at SERI. This research progam has experienced drastic funding cuts in recent years.

CONCLUSION

The natural gas industry recognizes that the continuing budget deficit places severe constraints on federal energy research dollars. Our total recommendation this year of $125.80 million is higher than previous years because of the

increasing urgency to promote end-use technologies and conservation. With the focus of the Administration, Congress and the public at large turning towards clean air problems, and a general consensus that natural gas has a major role to play in solving this problem, increased federal funding for research and development to increase natural gas supplies and utilize this gas more efficiently is necessary to implement the national goals. However, our recommendation is still conservative, requesting funding for only those technologies that are essential and prudent for the orderly development of new, domestic gas supply and utilization technologies. If Congress adopts our research recommendations, the nation will, over the long term, improve its energy supply security and energy efficiency.

Testimony of Charles J. Mankin, Chairman

ACTION COUNCIL FOR COORDINATED OIL AND GAS RESEARCH AND DEVELOPMENT (ACCORD)

Before the Energy & Natural Resources Committee
Subcommittee on Energy Research & Development
Honorable Wendell Ford , Chairman
July 11, 1989

Mr. Chairman, it is with great concern that I appear before this subcommittee this morning to discuss the FY90 authorization for fossil energy research and development. The Action Council for Coordinated Oil and Gas Research and Development (ACCORD) was organized to endorse the recommendations of the Energy Research Advisory Board's report "Geoscience Research for Energy Security." ACCORD is comprised of more than 80 organizations of government officials, national, state, and regional associations, universities and research organizations, and petroleum experts in private life.

America is now at an important crossroads. In 1989 and 1990, Congress and the new Administration, in cooperation with the states and America's oil and gas producers, must make a fundamental choice about America's energy future: Effective abandonment of America's remaining oil and gas resource base in favor of imported fuels from the Persian Gulf, OR research and development to allow economic production of as much as 100 billion barrels of America's 325 billion barrel remaining oil resource. If we act forthrightly and cooperatively through an integrated policy of incentives, research, and technology development, we can sustain and improve our domestic production until economic and environmentally sound alternatives come to the forefront.

Low prices and aging reservoirs are causing the nation's producing oil and natural gas wells to be abandoned at an alarming and accelerating rate. That's a problem because plugging and abandoning the wells bars future economic access to the reservoirs thus permanently abandoning the remaining oil and gas resource. Meanwhile, America's dependence on foreign oil and refined products has exceeded 45 percent and approaches 50 percent.

As much as 100 billion barrels of this remaining oil resource and an appreciable amount of our gas resource could be recoverable at reasonable prices through improved geoscientific understanding of the resource base, advanced extraction technologies, and adequate economic conditions and incentives to promote their application. But if these geoscientific, technological, and economic improvements are not achieved soon, our opportunity to produce this remaining resource in known fields may be lost forever.

America is going out of the oil and gas recovery business. While they have done everything possible within the bounds of rational business practice, the majors are shifting their exploration budgets increasingly abroad, importing ever larger quantities of cheap foreign oil, and making the bulk of their domestic profits in downstream refining operations. They have cut their U.S. exploration and production research budgets sharply. The non-integrated, independent domestic oil and gas operators lack the revenues, financial backing, and technological sophistication to perform the research necessary to apply the needed new technologies to produce America's remaining oil and gas resources.

If we hold to our present course, the cost of imported crude and refined products in constant dollars will rise from $44 billion in 1988 to $120 billion by 2000. Wouldn't those dollars be much more effective if cycled through the domestic economy rather than those of foreign producers? Both DOE and the Commerce Department have concluded that this growing dependence on foreign oil represent a real threat to U.S. national security, leaving America -- and her allies -- extremely vulnerable to economically or politically motivated supply disruptions or world oil price escalations. It is time to change course.

Prioritized, integrated, coordinated, problem-oriented, interdisciplinary oil and gas research holds great promise. But to make it happen the nation, at the federal and state level, must choose an integrated and cooperative policy of incentives and R&D. Some of the states, including Texas and Oklahoma have passed incentive legislation. The Finance Committee will soon hear testimony on a bill introduced by Senator Domenici to restore limited Federal tax incentives to stimulate domestic production from enhanced oil recovery techniques . Through incentives, Congress can assure future access to America's massive remaining oil resource base. Through focused and expanded R&D, Congress can assure improvements in geoscientific understanding of the resource and development of advanced recovery technologies that, given a stable economic environment, have the potential to recover as much as 100 billion incremental barrels of oil.

ERAB called for DOE to consolidate 17 programs of hydrocarbon geoscience research existing without coordination under 3 different assistant secretaries into one single office reporting to the Secretary. But DOE responded by adding two new bureaucratic offices, numbers 18 and 19: the Office of Geoscience Research (OGR), and the Hydrocarbon Geoscience Research Coordinating Committee (HGRCC). While we are pleased that -- after a prolonged search -- DOE has appointed a highly qualified Director for OGR and a strong staff, we are concerned that the office's charter is not sufficient to address ERAB's recommendations and that it has no budget of its own. We fear that the HGRCC promises to serve only as the battleground for bureaucratic turf battles within DOE and between DOE and other agencies. The HGRCC has completed a draft geoscience research strategy. We look forward to participating in public review and comment on the strategy document. The House has directed DOE to prepare an implementation plan to based on the geoscience strategy, including funding options. The Senate should concur with the House on this directive.

Improved geoscientific understanding of reservoir heterogeneities and basin-specific conditions and development of advanced secondary and tertiary extraction technologies could allow some 30 - 50 billion barrels of unrecovered mobile oil in known reservoirs to be recovered. In addition, such advances could enable production of some 35 to 50 billion barrels of immobile oil, oil that is trapped in the rock by viscous and capillary forces. Combined, these 60 - 100 billion barrels of oil are more than enough to restore and sustain current production levels for the foreseeable future. And in that time period, other novel extraction techniques could result in even more substantial recoveries.

According to Gas Research Institute, some 583 trillion cubic feet of domestic gas resources could be economically recovered at prices below $ 3 per Mcf. As with oil, there is a significant potential for infill drilling to drain known gas reservoirs more thoroughly, encounter undrained "lenses" of gas, and more fully develop deep gas resources. Unconventional gas resources, including tight gas formations, methane gas from coalbeds, and Devonian shale gas are also significant and substantial resource targets. Collectively, the benefits of improved geoscientific understanding and characterization of the resource and advanced extraction techniques could triple current proved gas reserves.

A NATIONAL OIL AND GAS POLICY: To access these promising but threatened resources, we must act quickly to achieve four goals:

- Geoscientific understanding of the reservoirs must be improved.
- Advanced oil and gas extraction technologies must be developed.
- Economic access to known reservoirs through existing wells must be maintained.
- Economic conditions must prevail to permit applications of the improved technologies.

The choice is clear and the time is urgent: to develop America's remaining oil and gas resource base necessitates an integrated, strategic national oil and gas policy that includes four major integrated components:

R&D to sustain existing wells, improve geoscientific description of reservoir heterogeneities, and advance recovery technologies is the foundation upon which the other components of the policy must rest. Without these technologies, none of the other policies can be fully effective.

State and/or federal tax and other economic incentives are essential to encourage extended production life and application of advanced oil and gas technologies. Careful analysis must define the form and function of these incentives to prolong the life of existing wells and stimulate new reserves, while avoiding unacceptably high costs to public treasuries.

Cooperative environmental protection efforts are needed between, DOE, EPA, the states, and oil and gas operators that allow for both effective surface and subsurface protection and economic and competitive oil and gas production. We urge early and aggressive transition to natural gas fuels in the transportation, home heating, utility, and industrial sectors, where appropriate.

Complete and augment the U.S. strategic response to supply disruptions by filling the Strategic Petroleum Reserve (SPR) to its planned level of 750 million barrels, or more, retaining the Naval Petroleum Reserves as additional strategic reservoirs, that could be critical in the event of an oil or gas supply disruption.

A DOE OFFICE OF OIL AND GAS POLICY AND RESEARCH: Mr. Chairman, Senator Bingaman has introduced a bill to establish a DOE Assistant Secretary for Natural Gas. In our view, a better approach would be for the Department of Energy to create an Office of Oil and Gas, with its own assistant secretary, to consolidate and manage all current and future DOE oil and gas related research and policy analysis. The office would be comprised of the oil and gas personnel of the Office of Fossil Energy, and appropriate personnel from the Office of Policy Planning and Analysis, the Office of Energy Research, and the Office of Conservation and Renewable Energy. It would integrate and focus the oil and gas related programs according to a prioritized, problem-oriented, strategic plan, consistent with a national energy policy. Current Congressional authorization and appropriation committees and subcommittees would retain their present roles.

Proposed Research Plan

The DOE Office of Oil and Gas, as envisioned, should implement an inter-disciplinary program of research, integrated by a quantitative and analytically based strategic plan. Research would provide the understanding, tools, and technologies needed for successes in the applied research areas of field/reservoir frameworks, reservoir characterization, reservoir performance prediction, advanced extraction technology, stimulation and completion, and resource assessment and technology transfer. These interdisciplinary efforts would focus on solving the problems that limit the economic producibility of specific

resources in the most promising basins and formations (as defined in the strategic analysis) before these resources are abandoned. Complementing these interdisciplinary efforts would be additional research in the respective disciplines focused on advancing the scientific basis underlying the more applied, problem-oriented efforts.

By and large, the institutions currently performing the research under the current, diffuse and uncoordinated plan -- universities, the National Labs, federal and state research agencies and contract researchers -- would be the same under the integrated, focused program, because these institutions contain the requisite expertise and facilities. But their efforts would be focused on solving truly pressing problems of national strategic value.

APPROPRIATE SUFFICIENT FUNDS TO GET THE JOB DONE: In order to avoid the imminent abandonment of a substantial portion of the remaining domestic oil resource base, and to preserve the option of improving domestic oil and gas production and sustaining those levels, the Department of Energy and Congress should consolidate and accelerate funding for the oil and gas geoscience and extraction research programs in FY90. The leadership shown by Congress on the clean coal technology program is indeed commendable. We submit that a similar commitment is essential to meet America's urgent needs in oil and gas R&D. We must look at the national interest. America simply can not afford another year of dismantling and diffusion of her national oil and gas research capabilities.

Therefore, we urge this Congress and this new Administration most strongly to authorize and appropriate a consolidated FY90 oil and gas geoscience and extraction research and policy budget. At the current FY89 levels, that's about $102 million, including $49.9 million from the Interior and Related Agencies Appropriations, and $ 52.7 million from Energy and Water. To this, we recommend adding a total of $50 million, consistent with the ERAB recommendations of two years ago.

- For policy and strategic planning and analysis, allocate $1.5 million to oil and gas policy specifically.

- From the Office of Energy Research, Basic Energy Sciences program, incorporate the Engineering and Geosciences programs at the FY89 baseline level of approximately $33 million.

- From the Office of Conservation and Renewable Energy, include the geopressured research portion of the Geothermal/Geopressured research program at the FY89 baseline level of $19 million.

Thus, the research program funds under the Energy and Water Appropriation would total $53.5 million, approximately the same as the FY89 baseline.

- From the Office of Fossil Energy Oil and Gas Research Programs, include the Advanced Extraction and Process Technology Program at a level of $4 million dollars, and the enhanced oil recovery and tar sands programs at a combined level of $24 million.

- Include the Oil Shale program budget at $10 million.

- Include the unconventional gas research program of the Office of Fossil Energy at $12 million.

Thus the levels to be appropriated from existing programs under the Interior Appropriation Bill would total $50 million, or roughly the FY89 base level.

Finally, Mr. Chairman, we recommend a series of new integrated interdisciplinary oil and gas initiatives, in accordance with the strategic research plan, which relates these initiatives with the existing programs. Congress should authorize and appropriate $50 million dollars for this purpose in FY90 and rising to a maximum of $100 million as the budget permits over the next two years.

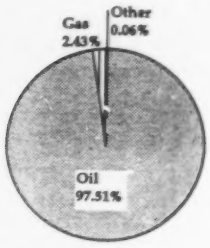
This proposal recognizes the fiscal responsibilities and constraints of the Congress and the Administration. Much of the funding for this essential research can be made available by consolidating the programs as described above. All of these programs were identified as oil and gas geoscience related by ERAB. Where ERAB had recommended funding levels of $134.2 million for FY87 and $184.2 million by FY90, Congress appropriated $102.6 in FY89. Yet DOE requested only $78.1 for FY90. Within the programs under the Interior and Related Agencies appropriation, DOE's request for FY90 of $28.6 million represents fully a 43% decrease below the current year.

The program recommended by ACCORD and its members totals $152 million -- some $32 million less than ERAB conservatively estimated as necessary to get the job done in FY90.

A commitment to these implementation steps, and to the modest budget we've recommended, will begin, finally, to restore a balance between national oil and gas research priorities and the national energy requirements of the nation for now and well into the future. Such a program and a budget will provide the time we so desperately need to develop alternative fuels to enhance national security, promote wise economic growth, and keep America internationally competitive as we move into the next century.

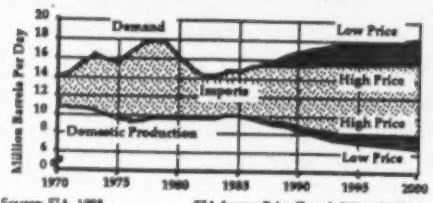
I urge your thoughtful consideration and adoption of these proposals and I thank you for your time this morning. I would be happy to answer any questions you or the members of the subcommittee may have.

Figure 1: Demand for Energy in Transportation Sector



Source: EIA, 1988

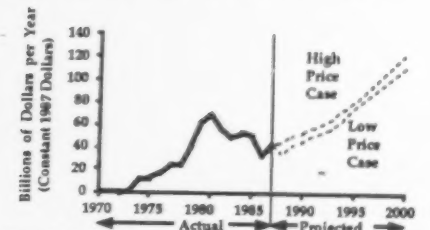
Figure 2: U.S. Dependence on Imported Crude Oil and Refined Products



Source: EIA, 1988

EIA Lower Price Trend: $13 to $25/bbl
EIA Upper Price Trend: $18 to $40/bbl

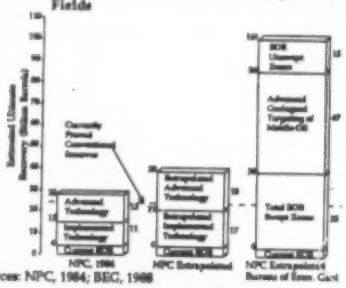
Figure 3: Cost of Imported Oil and Refined Products



Source: EIA, 1988

EIA Lower Price Trend: $13 to $25/bbl
EIA Upper Price Trend: $18 to $40/bbl

Figure 4: Estimated Additional Oil Recovery from Known Fields



Sources: NPC, 1984; BEC, 1988

Table 1: Recommendations for Consolidated FY90 DOE Oil and Gas Research & Development ($Millions)

	UNCONSOLIDATED				CONSOLIDATED
CONSOLIDATE UNDER NEW DOE OFFICE OF OIL & GAS:	FY87 (ERAB Base)	FY88 Actual	FY89 Actual	DOE/Admin FY90Request	ACCORD FY90 Recomm.
Energy & Water Appropriation					
Office of Policy Planning Analysis					
Oil & Gas Policy Analysis	*	*	*	*	7.5
Office of Energy Research (BES)					
Engineering	16.1	14.7	15.3	15.8	up to 15.3
Geoscience	15.4	14.3	17.8	18.3	up to 17.8
Office of Conservation & Renewables					
Geothermal/Geopressured R&D	20.8	20.7	19.6	15.4	up to 19.6
Subtotal, ENERGY & WATER	80.2	81.7	82.7	69.5	up to 54.2
Interior Appropriation					
Office of Fossil Energy					
Advanced Extraction & Process Tech	3.8	3.5	4.4	4.6	4.4
Enhanced Oil Recovery/Tar Sands	11.2	14.4	23.6	18.2	23.0
Oil Shale	11.0	9.5	10.5	1.7	10.5
Unconventional Gas Research	8.0	10.5	11.4	4.1	11.4
Subtotal, INTERIOR	34.0	40.0	49.9	28.6	49.9
TOTAL CONSOLIDATED PROGRAMS	86.3	91.7	102.6	78.1	up to 104.1
ADD NEW INTEGRATED OIL & GAS INTERDISCIPLINARY INITIATIVES	—	—	—	—	80.0
TOTAL INTEGRATED PROGRAM	86.3	91.7	102.6	78.1	up to 184.1
ERAB Recommended Level		134.2	139.2	184.2	184.2
Difference		(42.5)	(36.6)	(106.1)	(80.1)

* Previously included in other budgets; could be reduction from the former budget lines.
Note: Totals may not add due to independent rounding.

STATEMENT BY FRANK C. SCHORA, PRESIDENT, M-C POWER CORPORATION
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
July 11, 1989

Mr. Chairman and Members of the Subcommittee:

My name is Frank Schora. I am president of M-C Power Corporation, a company formed for the purpose of scaling up and commercializing the Molten Carbonate Fuel cell System. A new concept is being used, known as the IMHEX™ design which should significantly reduce the cost and complexity in the evolution of the technology from laboratory to commercial size.

Presently, three tests have been conducted using the IMHEX design and I am pleased to report that they give indications of a fundamental breakthrough in the major problem remaining in the development of the molten carbonate fuel cell technology, that of electrolyte management. With this internal manifold design no loss or redistribution of the carbonate electrolyte in the stack has occurred in these tests which has been a problem that has confounded molten carbonate development to date. With this breakthrough, we can now project stack endurance that will be acceptable for commercial use.

M-C Power, created in 1987 is a capitalized, shareholder owned corporation. The Institute of Gas Technology (IGT) has contributed its IMHEX technology and future technical support for a share of the corporation. Other shareholders have contributed the capitalization necessary for M-C Power to aggressively pursue its goal.

Since it has been established with this one goal and has stockholders investing because of their interest in seeing the corporation achieve commercialization of the molten carbonate fuel cell, M-C Power will be particularly focused and consequently very efficient in pursuing this objective.

A molten carbonate fuel cell electrochemically reacts fuel and air to directly produce electricity. An integrated coal gasifier/molten carbonate fuel cell power plant can use abundant domestic coal to produce electricity at an efficiency approaching 55% compared to 33% for conventional coal based systems and 45% for other advanced electric power generating concepts. When using natural gas as fuel, it is possible to achieve efficiencies in excess of 60% with certain system configurations. Its modular nature allows its use in a wide range of sizes and applications, from a few hundred kilowatts to multi-megawatts and from small on-site natural gas fired cogeneration systems to coal fueled baseload utility power plants. Because a molten carbonate fuel cell operates at 1200°F, waste heat produced as a by-product of the electrochemical reactions can be recovered at sufficiently high temperatures to allow a wide range of use in cogeneration and industrial applications.

A molten carbonate fuel cell system can be used to retrofit older coal fired power plants. An independent system analysis showed that such a coal gasification/molten carbonate fuel cell system can achieve a 99.5% reduction in SO_x and an 84% reduction in NO_x. For new molten carbonate fuel cell power plants which would have a coal to

electrical power efficiency approaching 55%, a 42% reduction in both fuel consumption and carbon dioxide emissions can be realized when compared to a conventional coal fired steam power plant. Such an efficiency gain can have a significant impact on reducing carbon dioxide additions to the atmosphere and thereby could lessen the possible greenhouse effect.

The successful development of molten carbonate fuel cell systems will provide significant benefits to the United States. In addition to its fuel conserving high efficiency and its essentially pollution free operation, it will enable the U.S., to develop as the need arises, on site ie. already distributed power generation for sale either by the utilities or by cogenerators. This locally generated power will decrease the need for; 1) siting major new power plants and 2) significant installation of new electrical power distribution systems. We must recognize that the public is becoming generally adverse to perceived environmental and health issues which consequently make permitting of such activities increasingly difficult.

M-C Power has created a Program Advisory Group consisting of representatives of several utilities and industrial companies interested in future power generation. Meetings of this group have had in attendance representatives from DOE, the Electric Power Research Institute and the Gas Research Institute. The group will assist us in guiding our development work so that we will create molten carbonate fuel cell systems which will be of maximum benefit to the country.

M-C Power's prime objective will be to scale up to commercial size and manufacture molten carbonate fuel cell stacks. Our plans are to build stacks based on individual cells having a cross sectional area of about 8 to 10 sq. feet. A fuel cell stack consists of such cells stacked one on top of the other so that the required electrical power output can be achieved.

M-C Power is working under a DOE contract with IGT and Combustion Engineering to develop the IMHEX™ concept. IGT, who has been the pioneer in the development of the molten carbonate fuel cell concept, will continue its R&D activities and will work toward improving components using the least expensive materials commensurate with the cell endurance necessary for commercial acceptance.

Combustion Engineering (CE) will focus on the areas of design and manufacture of the fuel cell stack support systems. Their responsibilities will involved optimization of the support systems design for both low power cogeneration systems as well as large multi-megawatt coal based systems. They will also provide engineering and manufacturing assistance to M-C Power in the stack development activity. In the future, Combustion Engineering will provide the marketing and sales strength to M-C Power under a separate agreement. Combustion Engineering is one of the largest world wide fabricators and suppliers of coal based electric power generating systems and has an excellent understanding of industry needs and how to effectively market in this area.

When I reported to this subcommittee last year, I mentioned our new concept of molten carbonate fuel cell and stack design which our team had termed "IMHEX". It is coined from the concept of internally manifolded heat exchanger. I am pleased to report that three 1 sq. ft. stacks have been designed, fabricated and tested based on this concept and have performed to expectation. These tests indicate the concept is sound, that fabrication of the separator plates which were based on the actual stamping requirement of a large commercial size plate is possible and appears to be cost effective based on ongoing manufacturing studies. What was also learned from these first three successful tests was that the use of internal manifolding of gases within the stack, which is being pioneered in the U.S. by the M-C Power team, has many benefits in overcoming some of the problems, such as external manifold leakage which the older designs encounter with aging and shrinkage of the stack components over prolonged operation. As previously mentioned, we believe this design solves the major problem of electrolyte management. It greatly improves the ability to accurately load the carbonate electrolyte in the cells and prevents movement or "pumping" of the electrolyte in the stack. Both of these achievements contribute to the necessary stabilization of the electrolyte inventory in the stack. Manifolds conduct the fuel and oxidant gases to the individual cells that make up the stack.

In order to meet our schedule which should see the introduction of commercial size stacks for demonstration and prototype application in the FY 94 time frame we are now procuring the large equipment necessary for the manufacture of the larger components. We recently moved into a new building in Burr Ridge, Illinois which will house these prototype manufacturing facilities and the necessary large scale test stands.

Thanks to the assistance of this subcommittee and others, we have the funding necessary to carry this program through the end of FY 89. We anticipate that three additional years will be necessary to see us into actual prototype production of these commercial size stacks which will be tested both at our facilities and by interested co-generators and utilities.

Because scale-up of Molten Carbonate Fuel Cell systems is underway by three DOE contractors, each of which is pursuing this objective on a different design basis, we feel it is not appropriate to select a single approach at this time but to fund each of the three contractors at an $8 million level for FY 90. This $24 million will be well spent, as funding levels in other countries for this very promising technology will be significantly higher. In the out years M-C Power presently anticipates funding requirements of $10 million in FY 91 and $12 million in FY 92 at which time large commercial sized stacks should be under test. At that time, M-C Power would look to participation in a clean coal program to see this new power generating concept to commercial realization.

I thank you for the opportunity to present this information to this subcommittee and would be pleased to answer any questions.

THE FY 1990 FOSSIL ENERGY BUDGET PROPOSAL

Testimony of

Gary A. Styles
Manager, Advanced Fuel Utilization
Southern Company Services, Inc.
to the
Committee on Energy and Natural Resources
Subcommittee on Energy Research and Development
U.S. Senate

July 11, 1989

Mr. Chairman and Members of the Committee:

Summary

The purpose of this testimony is to request authorization for the continued operation of the Wilsonville Advanced Coal Liquefaction Research and Development Facility. The continuation of this project is of vital importance to the energy security of the United States because we continue to be vulnerable to another oil crisis through either high prices or shortages. Direct coal liquefaction can cap the price the United States pays for imported oil and can also help reduce the trade deficit. The coal liquefaction research program at Wilsonville has resulted in significant improvements in the economics of coal-derived liquids - for example, a 57 percent decrease in cost between 1983 and the present. However, more work needs to be completed before coal-derived liquids can economically compete with petroleum. The objective of the Wilsonville research program is to reduce the cost of coal-derived liquids by 20 percent from the present cost of about $40 per barrel to $32 per barrel, an oil price that could be reached in the next five years even without a crisis. Over the next year, the Wilsonville project plans to focus its research on obtaining higher yields from bituminous coals, on testing less expensive coals, and on improving catalysts and process configurations. If this can be accomplished, it may be possible to have this technology ready before another oil crisis occurs. If the Wilsonville program is terminated, the government will have to spend $30 to $50 million during the next oil crisis to build and operate a similar facility. More important, it will take at least five years to re-learn the operating and maintenance techniques that are presently well understood at Wilsonville.

Introduction

Due to declining domestic petroleum reserves and production, increased domestic oil consumption, and increased dependence on imported oil, the United States is very vulnerable to another oil crisis. Presently, oil is the major source of transportation sector fuels and there are no available near-term alternatives. With continued research, direct coal liquefaction can potentially provide an alternative fuel source in as little as 5 to 10 years.

Recent developments have shown that as much as 78 percent of low-ash, high-carbon eastern bituminous coals can be converted into distillate fuels. In addition, revised estimates of the economics of direct coal liquefaction technologies show that the cost of producing coal-derived liquids has been reduced from $93 per barrel in 1983 to $40 per barrel in 1988 through improvements in technology and plant design. If commercialized, coal-derived liquid fuels can reduce U.S. dependence on imported oil and can also reduce the U.S. balance of payments deficit.

Wilsonville is the largest operating coal liquefaction pilot plant in the United States but it is also the smallest size at which steady-state evaluations of advanced coal liquefaction technology can be conducted. The facility, which was built without federal funds, cost over $25 million to construct. In addition, an important resource at Wilsonville is a staff of 95 experienced engineers, chemists, operators, and maintenance personnel with an average of over 10 years experience in coal liquefaction research. Wilsonville has the reputation of being one of the best coal liquefaction research projects in the world. Japan, the United Kingdom, Canada, Australia, and the People's Republic of China all continue to support development of direct coal liquefaction as a method of reducing dependence on imported oil. If the Wilsonville program is terminated, the United States will lose its leadership in this technology which it needs in order to be ready for the next oil crisis.

U.S. Dependence on Imported Oil

Less than three years ago, 27 percent of the U.S. oil supply was imported. In 1988, the foreign share was about 47 percent and is expected to rise to 50 to 70 percent in the 1990's.[1,3] In 1987, the cost for imported oil was $47 billion. By the year 2000, the import oil bill is estimated to be $200 billion. Large oil imports not only leave the United States vulnerable to oil embargoes and energy crises, they also adversely affect the U.S. trade deficit and the ability to pay for imports.[4] In 1988, imported oil accounted for $38 billion (through November), or over 30 percent of the total U.S. trade deficit.

The increase in U.S. dependence on imported oil is caused by both increased oil consumption due to lower oil prices and by declining oil production due to decreased exploration. Oil consumption was five percent higher in mid-1987 than it was for the corresponding period in 1985. Drilling activity in the United States reached a post-World War II low during 1986.[1] In 1981, as many as 4,500 drilling rigs were active. For the period 1982-1985, an average of 2,400 rigs was active. This level of activity was just sufficient to maintain a constant level of reserves. In the last half of 1986 and first half of 1987, only 800 rigs were active. While the full effect of this drop on production has yet to be felt, crude oil production has already dropped from 9.1 million barrels per day in February, 1986, to 8.3 million barrels per day in January, 1987, and averaged only 8.1 million barrels per day for 1988.[4]

The major reason for this drop in drilling activity and production is low oil prices. According to Robert L. Hirsch, Vice President for ARCO Oil and Gas Company, "Because people are generally happy with lower energy prices, and

because the country tends to be short-term oriented, there appears to be a low probability of action before the problem becomes severe."[1]

The current volatility in oil prices has adversely affected petroleum industry planning. The lag between planning and new production is on the order of 5 to 10 years. If another energy crisis occurs, it will take 5 to 10 years before the U.S. economy can adjust as evidenced during the crises of the 1970's.

The principal importance of oil is that it is presently the primary source of fuel for motor vehicles and aircraft. Moreover, oil represents one-fourth of the total U.S. energy use and is the only major energy resource in which the United States produces less than it consumes. While natural gas or coal can be used to replace oil for some industrial applications, most conversions to natural gas have already been made. Unlimited, low-cost natural gas cannot be relied upon to reduce U.S. dependence on imported oil. The high rate of drilling for natural gas between 1980 and 1986, compared to the 1970's, did not increase reserves because natural gas was being consumed at the rate at which it was being discovered. In the first half of 1987, drilling for natural gas was 33 percent below the same period in 1986. The impact of this reduced drilling activity has not yet been felt but will ultimately result in decreased supply and increased cost for natural gas.[1,4]

Due to low oil and gas prices and tighter environmental regulations, many energy consumers are switching back to oil or natural gas. Between 1990 and 2000, it is estimated that 89,000 megawatts of electric power generating capacity will be added in the United States.[7] Of this total, 46,700 megawatts will be combustion turbines or combined cycle capacity which will require premium liquid or gaseous fuels. This trend will increase U.S. dependence on imported oil.

While the United States is deficient in oil supply and production capability, it does have abundant resources of coal and oil shale that can be used to eliminate dependence on imported oil and reduce the balance of payments deficit. Coal accounts for 80 percent of the recoverable fossil fuel reserves in the U.S. but supplies on 23 percent of the energy consumed.[6] It is estimated that 625 billion barrels of liquid fuels can be produced from coal and oil shale, which far exceeds Saudi Arabia's present 166 billion barrels of reserves.[2]

Most of these arguments have been made before and were a primary justification for the synthetic fuel development programs of the late 1970's and early 1980's. Results from those programs showed that liquid fuels would cost as much as $93 per barrel. For a number of reasons, the present Administration eliminated support for further development of clean liquid fuels. In the face of this indifference, Congress has continued to support clean liquid fuel research at minimum levels throughout the 1980's through basic laboratory research and at pilot scale facilities such as the Wilsonville Advanced Coal Liquefaction R&D Facility. As a result, coal liquefaction technology has continued to improve. Amoco Corporation recently revised the estimated cost of coal-derived liquid fuels. The revised cost estimate was based on improvements made at the Wilsonville Advanced Coal

Liquefaction R&D Facility, on design improvements, and on changes in U.S. economic factors. Amoco's latest estimate shows that the cost, based on these improvements, of coal-derived liquids is down to $40 per barrel, a 57 percent decrease since 1983.*

Wilsonville Accomplishments

Some significant recent accomplishments of the Wilsonville facility are:

- From 1982 to 1985, integrated two-stage liquefaction (ITSL) was developed and demonstrated at steady-state conditions. Using an integrated system of a thermal reactor for the first stage and an ebullated-bed catalytic reactor as the second stage, 60 percent of typical eastern bituminous coal was converted to distillate fuel. This was a significant increase over previous systems, which typically converted 50 percent or less into distillate fuel. It was this breakthrough which caused Amoco to re-evaluate its cost estimate for coal derived liquids.

- In 1984, over 50 percent distillate was produced from low-rank western subbituminous coal by using an inexpensive disposable catalyst in the ITSL process.

- In 1985, the objective of the Wilsonville program was changed to emphasize research into fuels that can be used in the transportation sector rather than clean boiler fuels as in the early 1980's.

- In 1986, a mathematical model was completed which simulates the Wilsonville ITSL process.

- In 1987, staff was reduced by 15 percent and operating cost were reduced by 7 percent due to reduced funding. The quality of the research program was only minimally affected. The project is currently at minimum staffing for an effective research program.

- In 1987, a second ebullated-bed catalytic reactor was added and research into close-coupled two-stage liquefaction began. In late 1987 and early 1988, 78 percent distillate yield was produced from low-ash, high-carbon Appalachian coal.

Wilsonville Goals

The goal of continued coal liquefaction research at Wilsonville over the next two years is to reduce the cost of coal-derived liquids from the current $40 per barrel by another 20 percent to $32 per barrel. It is not unreasonable to expect oil prices to reach $32 per barrel in the next five years under non-crisis conditions. If coal-derived fuels can be produced for $32 per barrel, there is a reasonable possibility of commercializing direct liquefaction before the next oil crisis occurs. If coal liquefaction can be commercialized under non-crisis conditions, the price the United States has to pay for imported oil will be effectively capped. Commercialization can also help reduce the trade

deficit by replacing imported oil with fuels produced from the domestic coal reserves. Research over the next years will focus on:

- low-ash, high-carbon eastern bituminous coals which may increase the quantity of distillate yields.
- improved catalysts which may lower capital and operating cost, increase distillate yields, and improve product quality.
- improved process configurations which may lower capital and operating costs.

Wilsonville Capabilities and Private Sector Cost Sharing

The Wilsonville pilot plant has several unique features that make it well suited for continued coal liquefaction research. These include:

- A staff of 95 experienced engineers, chemists, operators, and maintenance personnel with an average of over 10 years experience in synthetic fuel research.
- Proven capital equipment valued at over $25 million that was purchased with funds from non-government sources [Electric Power Research Institute (EPRI), Southern Company Services (SCS), and Kerr-McGee Corporation]. The Wilsonville pilot plant includes two ebullated-bed catalytic reactors, an efficient Kerr-McGee Critical Solvent Deashing unit for ash removal, and all necessary support equipment such as waste water treatment and data acquisition systems.
- A non-proprietary research program that is designed to disseminate as much information as possible to industry.

Cost sharing for the Wilsonville project is provided by EPRI, Amoco Corporation, and SCS. Through 1988, 38 percent of the total project cost of $121.3 million has been provided by the above mentioned co-sponsors. All capital costs are paid by EPRI. In 1989 and 1990, we estimate that a minimum of $750,000 per year will be provided by co-sponsors. SCS is actively seeking additional private sector co-sponsors. In addition to cost sharing, SCS has implemented changes in the project organization that will save DOE $600,000 to $700,000 per year beginning FY'89.

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July 14, 1989
JUL 14 1989

The Honorable Wendell H. Ford
Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

On behalf of the members of the MHD Industrial Forum, we want to thank you for your incisive question to Secretary Wampler, at your Energy Research and Development hearing on Tuesday, as to why DOE refuses to fund MHD electric power generation and the other advanced clean coal technologies called for in the President's new Environmental Bill.

Magnetohydrodynamic (MHD) power generation offers the highest efficiency and most environmental advantages of all advanced coal-fired power system under development at DOE.

We would be very grateful if you would convey to Chairman Byrd, before the Interior Appropriations markup scheduled for Monday, the urgent need for the Senate to agree with the House-approved $42.9 million budget for MHD in FY 1990. This amount is needed to ensure that the current Proof of Concept (POC) Program is completed in 1993 at which time the construction and retrofitting of an MHD power unit to a conventional coal-fired power plant under a clean coal project can get underway.

MHD offers a prime example of DOE's antagonism toward coal, and fossil energy in general, over the past eight years. It now appears that DOE will continue this policy even while President Bush calls for a cleaner environment.

Coal-fired MHD electric power plants will extract virtually all SO_2 while reducing NO_x and particulate emissions to levels one third below EPA's New Source Performance Standards. Because of its efficiency (the highest of any coal-fired power system under development by DOE), MHD can cut CO_2 emission by 50% and consequently have a significant impact on global warming. Furthermore, all of this can be accomplished without any external cleanup devices such as scrubbers.

Those of us in the coal industry are hoping that DOE's attitude toward coal will change under the new management. Unfortunately, Assistant Secretary Wampler's response to your question indicates that DOE (and OMB) will not be in step with the President's call for "Energy Independence." As you stated at the hearing, U.S. petroleum imports continue to rise. Yet DOE new management continues to urge Congress to adopt an FY 1990 budget that devotes 22% of a ridiculously low fossil energy budget to develop coal, the nation's most abundant resource. While we support an aggressive nuclear R&D program, there is something basically wrong with a policy that devotes 50% of its total energy budget to non-defense nuclear programs while virtually starving the nation's principle energy resource. The fact is that coal will continue to fuel our power plants for the foreseeable future, and DOE's R&D programs should reflect this reality.

While DOE encourages industrial participation in its clean coal program and urges contractors to cost share projects, the department's policies offer little encouragement as to DOE's reliability as a partner.

The MHD community, for example, has met all of its cost-sharing obligations. (MHD is DOE's only R&D project that cost shares in accordance with a legislative formula, and may be the only program in its state of development that is cost shared at all!) Yet, DOE consistently omits funding in its budget for the POC Plan which the Department worked with industry and then submitted to Congress. DOE's attitude also is having an adverse impact upon the efforts of an industry task force seeking private funds needed to finance an MHD Clean Coal project beginning at the conclusion of the POC in 1993.

In testimony before committees of both Houses, Assistant Secretary Wampler repeatedly said that MHD is an excellent technology, but that it is too expensive and long term.

The fact is that MHD has met all of its technical and management schedules. Except for a slippage caused by a $37 million budget in FY 1989 in place of a $47 million as called for in the POC, the program would have been completed as planned in 1992.

If, as stated earlier, Congress provides $42.7 million in FY 1990, the program will slip only one year and add an additional $20 million. Even with the added cost, the total price for the six-year POC effort will be only $467 million.

MHD's environmental advantages and the opportunity it offers to encourage the use of all coals while allowing the United States to market a new technology worldwide certainly justify the investment.

Again, on behalf of the MHD community, I want to thank you for your interest.

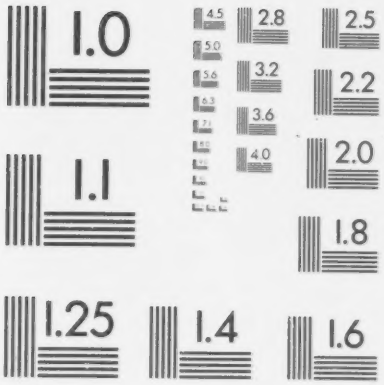
Sincerely,

Vincent J. Coates, Jr.
Vice President
MHD Industrial Forum

VJC/alw

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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